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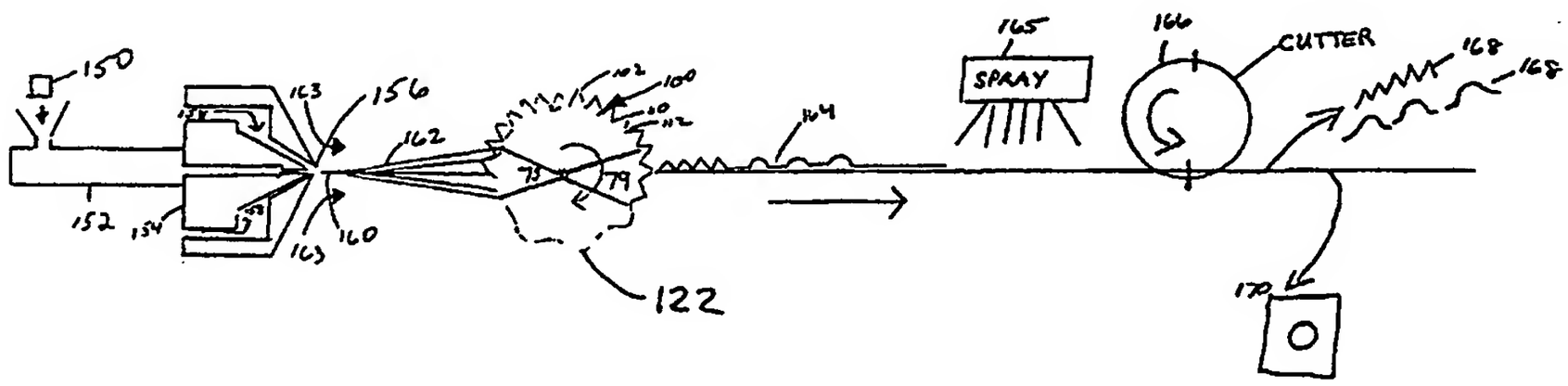

(57) Abstract

A method of manufacturing a non–woven material uses a contoured honeycomb drum with an outer microporous surface, more particularly with a contoured outer surface, for the manufacture of contoured non–woven fibrous materials. The method can use spunbonded, melt blown or electrostatic spun techniques for depositing solidify ing filaments on the microporous surface such that the non–woven material conforms to the contour of the drum, and then removing the non–woven material from the drum. The drum facilitates continous production of non–woven articles with three dimensional shapes such as surgical masks or pleated air filters. Additional materials may be added to the non–woven material to bridge between high points of a repeating three dimensional shape to obtain desired properties in a final product.

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METHOD AND APPARATUS FOR MANUFACTURING NON-WOVEN ARTICLES

Related Applications

This application claims priority to U.S. Patent Application Serial No. 09/193,582, filed November 17, 1998, and U.S. Provisional Patent Application Serial No. 60/149,270, filed August 17, 1999, the disclosures of which are incorporated herein by reference in their entirety.

Field of the Invention

This invention relates to a method of using a honeycomb drum with an outer microporous surface, more particularly with a contoured outer surface, for the manufacture of contoured non-woven fibrous materials.

Background of the Invention

Non-woven articles are used in applications that require materials to be air permeable. Some applications of non-woven materials are surgical masks and filter membranes. Since many applications that use non-woven material require disposable articles, the non-woven articles should be easily manufacturable and low cost. Some methods of manufacturing non-woven materials are spunbonded, melt blown processes and electro spinning of nano-fibers.

FIG. 1 illustrates the spunbonded process 10 for manufacturing non-woven materials. Thermoplastic fiber forming polymer 12 is placed in an extruder 14 and passed through a linear or circular spinneret 16. The extruded liquid polymer streams 18 are rapidly cooled and attenuated by air and/or mechanical drafting rollers 20 to form desired diameter solidifying filaments 22. The solidifying filaments 22 are then laid down on a first conveyor belt 24 to form a web 26. The web 26 is then bonded by rollers 28 to form a spunbonded web 30. The spunbonded web 30 is then transferred by a second conveyer belt 32 and then to a windup 34. The spunbonded process is an integrated one step process which begins with a polymer resin and ends with a finished fabric.

FIG. 2 illustrates the melt blown process 40 for manufacturing non-woven materials. Thermoplastic forming polymer 42 is placed in an extruder 44 and is then passed through a linear die 46 containing about twenty to forty small orifices 48 per inch of die 46 width. Convergent streams of hot air 50 rapidly attenuate the extruded liquid polymer streams 52 to form solidifying filaments 54. The solidifying filaments 54 subsequently get blown by high velocity air 56 onto a

take-up screen 58, thus forming a melt blown web 60. The web is then transferred to a windup 62. U.S. Patent Number 4,380,570 entitled "Apparatus and Process for Melt-Blowing a Fiberforming Thermoplastic Polymer and Product Produced Thereby" describes the melt blown process and is incorporated herein by reference in its entirety.

While non-woven materials can be manufactured by either the spunbonded or melt blown process there are difficulties associated with each process. For example, the newly manufactured non-woven material (e.g. melt blown web 60) tends to stick to the take-up screen 58. Further, the processes produce sheet material. Accordingly, to manufacture non-woven materials into three dimensional shapes, e.g. surgical masks and pleated filters, some form of post-processing is required.

Summary of the Invention

The present invention relates to a method for manufacturing non-woven articles. In one embodiment, the method includes providing a drum made of a tubular honeycomb member that forms an outer contour which is surrounded by a microporous layer, depositing solidifying filaments on the microporous layer to form a non-woven material that matches the contour of the drum, and removing the non-woven material from the drum.

In another embodiment of the present invention, the method for manufacturing non-woven articles further adds the step of providing a negative pressure to a part of the drum to conform the solidifying filaments to the contour of the drum.

In another embodiment of the present invention, the method of manufacturing a non-woven article also includes the additional step of providing a positive pressure to a portion of the drum to facilitate removing the non-woven material from the drum.

In another embodiment of the present invention, the method of manufacturing a non-woven article also includes the additional step of treating the non-woven material with additional supplements such as a stain repellent or coloring.

Another embodiment of the present invention, relates to a drum with a generally tubular honeycomb member that has an outer surface forming a contour, where the contour is covered with a microporous layer, for the manufacture of a non-woven materials.

In another embodiment of the present invention, the drum can have a negative pressure applied to a portion of the drum in order to help the non-woven materials conform to the contoured outer surface of the drum.

In another embodiment of the present invention, the drum can have a positive pressure applied to a portion of the drum in order to help remove the non-woven materials from the drum.

In another embodiment of the present invention, the drum can be made up of panels with different contoured outer surfaces to generate non-woven materials of different shapes from the same drum.

In another embodiment of the present invention, one or more additional materials may be added to the non-woven material to bridge a contoured surface or otherwise change desired properties of a final product.

Brief Description of the Drawings

This invention is pointed out with particularity in the appended claims. The above and further advantages of this invention may be better understood by referring to the following description, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic of a spunbonded process for manufacturing non-woven materials.

FIG. 2 is a schematic of a melt blown process for manufacturing non-woven materials.

FIG. 3A is a perspective view of an embodiment of the drum of the current invention, illustrating a contoured honeycomb tube with an outer microporous surface.

FIG. 3B is a partially exploded side view of the drum illustrating the mounting structure, vacuum apparatus, and V-belt drive groove.

FIG. 3C is a partially exploded perspective view of the drum structure.

FIG. 4 is a partial cross-sectional view of the drum taken along line 4-4 in Fig. 3A illustrating a pleated surface.

FIG. 5 is a partial radial view of the drum illustrating the honeycomb mesh.

FIG. 6 is a cross-sectional view of the drum taken along line 6-6 in Fig. 3A illustrating a contoured outer surface having a three dimensional surface.

FIG. 7 is a schematic of a process of the current invention for the manufacture of non-woven materials that substantially match the contoured outer surface of the drum.

FIG. 8 is a schematic of a process of the current invention for the post processing of non-woven materials after a three dimensional contour has been formed.

FIG. 9 is a schematic perspective view illustrating a first material and a second material bridging a three dimensional contour.

FIGS. 10A-10C are schematic perspective views illustrating three embodiments of three dimensional shapes that can be formed in a non-woven material by a process of the current invention.

Detailed Description of the Invention

Referring to FIG. 3A, shown is a drum 100 having a contoured outer surface 102 constructed in accordance with the teachings of the present invention. The contoured outer surface 102 may take many different shapes and forms. As shown, the drum 100 is made of a tubular honeycomb member 104 that is surrounded by a microporous layer 106. The microporous layer 106 is tack welded to the tubular honeycomb member 104 and may be finely electroetched stainless steel having numerous holes on the order of 0.010 inches (0.25 mm) in diameter, such that the microporous layer 106 is about fifty percent open. A frame 108 rotatably supports the drum 100. The material for the tubular honeycomb member 104 can be, but is not limited to, stainless steel.

Referring to FIG. 3B, the drum 100 is supported by the frame 108 or frames, so that the drum 100 can be rotated as the solidifying filaments are continuously applied. FIG. 3B also shows a pipe 70 with a vacuum port 72 and a bearing surface 74. The pipe 70 is located in the center of the drum 100. The pipe 70 also has a slot 73 that is in communication with the vacuum port 72 to draw a negative pressure 75 through a sector of the drum 100 to conform the solidifying filaments to the contour. See FIG. 7. Also shown is V-belt drive 76 which can be used to rotate the drum 100 by any conventional source known to those skilled in the art, such as a variable speed motor.

Referring to FIG. 3C, the drum 100 includes inner support bars 78 which are located throughout the drum 100. The inner support bars 78 provide stiffness to the drum 100 and allow a negative pressure 75 or positive pressure 79 to be provided to a portion of the drum 100, as shown in FIG. 7. FIG. 3C also shows that the drum 100 includes a plurality of panels 80 that can attached to the drum 100 by a variety of means (e.g. fasteners or clips). The panels 80 can be made to form any desired contoured outer surface 102.

Referring to FIG. 4, shown is a partial cross-sectional view of one embodiment of the drum 100 of the present invention. The drum 100 has a contoured outer surface 102 that has the shape of alternating peaks 110 and valleys 112. The contoured outer surface 102 is covered by

the microporous layer 106. As will be further shown, the contoured outer surface 102 with alternating peaks 110 and valleys 112 can be used to form pleated-shaped non-woven articles.

Referring to FIG. 5, shown is a partial radial view of the drum 100 illustrating a rectangular mesh 114 of tubular honeycomb member 104. The mesh 114 consists of alternating multiple rows of mesh holes 116, where each row is offset from the previous row. Each mesh hole has a length 118 and width 120. In one embodiment the mesh hole length 118 is about 0.5 inches (1.3 cm) and the width 120 is about 0.25 inches (0.64 cm). By using a rectangular mesh 114, the honeycomb member 104 can be readily formed into a circular contour.

Referring to FIG. 6, shown is another partial cross-sectional view of the drum 100 illustrating a three dimensional form 122 that is attached (e.g. tack-welded) to the drum 100. The three dimensional form 122 also has honeycomb construction and can be formed by, but not limited to, electrical discharge machining. The three dimensional form 122 is also covered by the microporous layer 106. As will be further shown, the three dimensional form 122 can be used to make, for example, a surgical mask shaped article.

FIG. 7, shows one process for manufacturing contoured non-woven articles. Thermoplastic forming polymer 150 is placed in an extruder 152 and passed through a linear die 154 containing about twenty to forty or more small orifices 156 per inch of die 154 width. Convergent streams of hot air 158 rapidly attenuate the extruded liquid polymer 160 to form solidifying filaments 162. The solidifying filaments 162 subsequently get blown by high velocity air 163 onto the contoured outer surface 102 of drum 100. Note that the method illustrated in FIG. 7 for generating the solidifying filaments 162 is a melt blown process, but a spunbonded process, or any other method for generating the solidifying filaments 162 can be used, such as electrospinning of nano-fibers using an electrostatic spun technique. Melt blown process equipment is available from Biax Fiberfilm Corporation located in Wisconsin.

The drum 100, which is rotating, has a contoured outer surface 102, which can have a combination of shapes, for example, alternating peaks 110 and valleys 112 or a series of three dimensional forms 122. Once the solidifying filaments 162 are deposited on the drum 100, a vacuum or negative pressure 75 can be applied to a portion of the drum 100 to conform the solidifying filaments 162 to the contoured outer surface 102, to prepare closely matching contoured non-woven materials 164.

After the contoured non-woven materials 164 are formed, the rotating drum 100 rotates to a point where the contoured non-woven materials 164 are removed from the drum 100. Positive pressure 79 can optionally be applied through a portion of the drum 100 to facilitate removing the contoured non-woven materials 164 from the drum 100. Once off the drum 100, the contoured non-woven material 164 can be post processed in a variety of post processing operations, for examples by application of a spray 165. The treatment can consist of adding various supplements such as flame retardents, stain repellents, colored dyes, and the like, or to change the shape, feel, texture, or appearance of the contoured non-woven material 164.

FIG. 8 is an expanded view of additional optional post processing performed on the contoured non-woven material 164. In addition to the treatment operations discussed above, a first material 171 may be added to the contoured non-woven material 164 in order to achieve desired properties in a final product 168. The first material 171 may be a non-woven material or any other material, based on properties required in the final product 168. For example, some materials that can be used for the first material 171 are absorbent substances or charcoal or other filter materials known to those skilled in the art. The first material 171 may be selected based on desired material properties such as pore size, fiber diameter and length, basis weight, and density.

FIG. 8 shows a process step 180 for adding the first material 171 to the contoured non-woven material 164. The process 180 for adding the first material 171 to the contoured non-woven material 164 may be a spunbonded process or a melt blown process for non-woven materials. Alternatively, loose fill or pre-formed sheet goods, with or without an adhesive treatment, can be deposited on the non-woven material 164. If the first material 171 is a material other than a non-woven material, a person skilled in the art can choose the appropriate method for manufacturing the desired material. Additional process 172 can add a second different material 173 on top of the first material 171. The same considerations used to select the first material 171 can be used to select the second material 173.

A covering material 182 from a source 181 may be placed over the contoured non-woven material 164. The covering material 182 captures or retains the first material 171 and the optional second material 173 within the contoured non-woven material 164. Some materials that may be used for the covering material 182 are organic fibers, inorganic fibers, and polymers, which can be in the form of woven or non-woven sheet goods, films, and the like, and which may or may not be porous. The covering material 182 may be adhered or bonded to the

contoured non-woven material 164 by a variety of processes 184 known to those skilled in the art, such as a pair of rollers, a heated die, etc. to seal and/or laminate the layers. Additional layers of materials and coverings may be applied, as desired.

FIG. 9 illustrates the presence of the first material 171 and the second material 173 in the valleys of a pleated contoured non-woven material 164. The first material 171 and the second material 173 effectively bridge 174 the peaks 110 in the pleated material 164. The bridge 174 may be made up of just the first material 171, a combination of the first material 171 and the second material 173, or a plurality of different desired materials. The bridge 174 may bridge or partially or fully fill any three dimensional contour.

The process of FIG. 8 results in a wide variety of articles which can be used in a variety of applications. One embodiment resulting from the process of FIG. 8 consists of a non-woven material 164, where the first material 171 added is a carbon filtration material and a covering material is applied overall. Another embodiment consists of a non-woven material 164, where the material added results in a varying gradient filter article. The varying gradient filter article has multiple filter layers, each layer can have its own filter pore size. Each layer in the varying gradient filter article can trap different particle sizes. In addition, another embodiment of the process of FIG. 8 consists of a non-woven material 164, where the first material 171 added can be a high loft material, so that the resultant article can be used for absorption of oil or other liquid. Other materials can be selected by a person skilled in the art, based on the particular application and performance sought

FIGS. 10A-10C show additional three dimensional contours which can be manufactured by the process in accordance with the invention, such as half tube 175, multinodal 176, and pyramidal or frustoconical 177 contours. Other contours, both regular and irregular, will be apparent to those skilled in the art based on the teachings herein.

Referring back to FIG. 7, after any post processing has been completed, the contoured non-woven material 164 may pass through a cutter 166, to cut the contoured non-woven material 164 into the desired article or final product 168. The cutter 166 may be a die. water jet, laser, or any other apparatus capable of trimming to the desired contour. Any waste 170 after the cutting operation can either be disposed of or recycled. Accordingly, non-woven contoured articles such as wipes, filters, face masks, sorbent products, insulation, clothing, and the like can be rapidly produced from polypropylene, polyester, or other materials in a continuous process at low cost.

Variations, modifications, and other implementations of what is described herein will occur to those of ordinary skill in the art without departing from the spirit and the scope of the invention as claimed. Accordingly, the invention is to be defined not by the preceding illustrative description, but instead by the following claims.

What is claimed is:

1. A method of forming a non-woven article comprising the steps of:

providing a drum comprising:

a generally tubular honeycomb member having an outer surface forming a contour; and

a microporous layer covering at least a portion of the contour;

depositing solidifying filaments on the microporous layer to form a non-woven fibrous material substantially matching at least a portion of the contour; and

removing the fibrous material from the drum.

2. The method of claim 1 further comprising the step of providing negative pressure to at least a portion of the honeycomb member to conform the solidifying filaments to the contour.

3. The method of claim 1 further comprising the step of providing positive pressure to at least a portion of the honeycomb member to facilitate removing the fibrous material from the drum.

4. The method of claim 1 further comprising the step of post processing the non-woven material.

5. The method of claim 1 further comprising the step of trimming the article from the non-woven material.

6. The method of claim 1 further comprising the step of adding an additional material to the non-woven fibrous material.

7. The method of claim 6 further comprising the step of capturing the additional material with a covering.

8. A drum for forming non-woven articles, the drum comprising:

a generally tubular honeycomb member having an outer surface forming a contour; and

a microporous layer covering at least a portion of the contour.

9. The invention according to claim 8 further comprising:
a frame for rotatably supporting the drum; and
for rotating the drum.

10. The invention according to claim 8 further comprising:
a pipe located inside the drum, the pipe forming:
a vacuum port; and
an aperture in the pipe in fluidic communication with the vacuum port.

11. The invention according to claim 10, the pipe further forming
a pressure port; and
an aperture in the pipe in fluidic communication with the pressure port.

12. The invention according to claim 8 further comprising structural members for supporting the honeycomb member.

13. The invention according to claim 8 wherein the honeycomb member comprises a plurality of removable sectors.

14. The invention according to claim 8 wherein the contour is formed in the honeycomb member.

15. The invention according to claim 14 wherein a portion of the contour comprises alternating peaks and valleys.

16. The invention according to claim 8 wherein the contour is mounted to the honeycomb member.

17. The invention according to claim 16 wherein a portion of the contour comprises a three dimensional form.

18. The invention according to claim 17 wherein three dimensional form comprises:
an additional honeycomb member and
a microporous layer covering at least a portion of the three dimensional form.

19. An article produced in accordance with the method of claim 1.

20. An article produced in accordance with the method of claim 6.

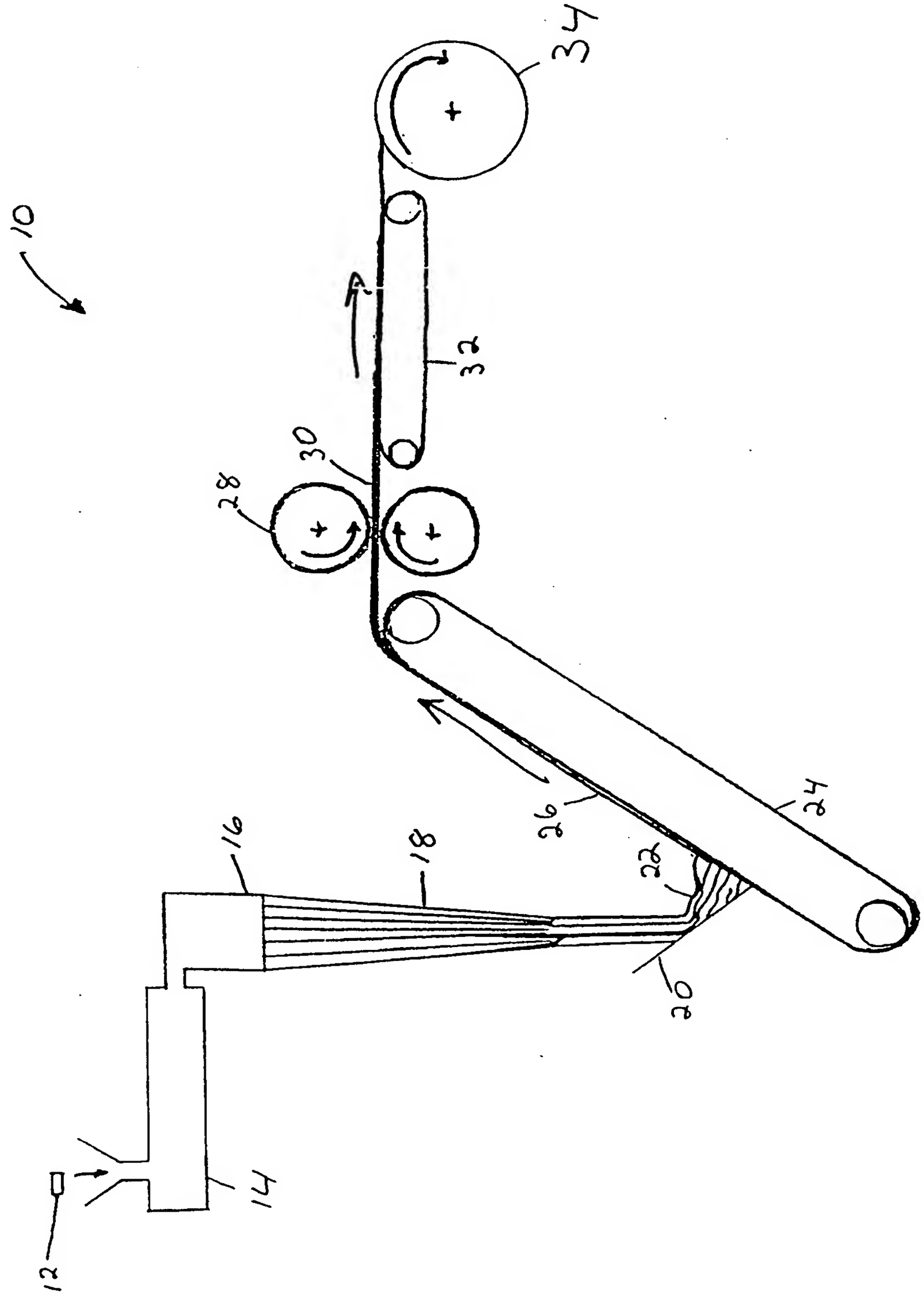


FIG. 1

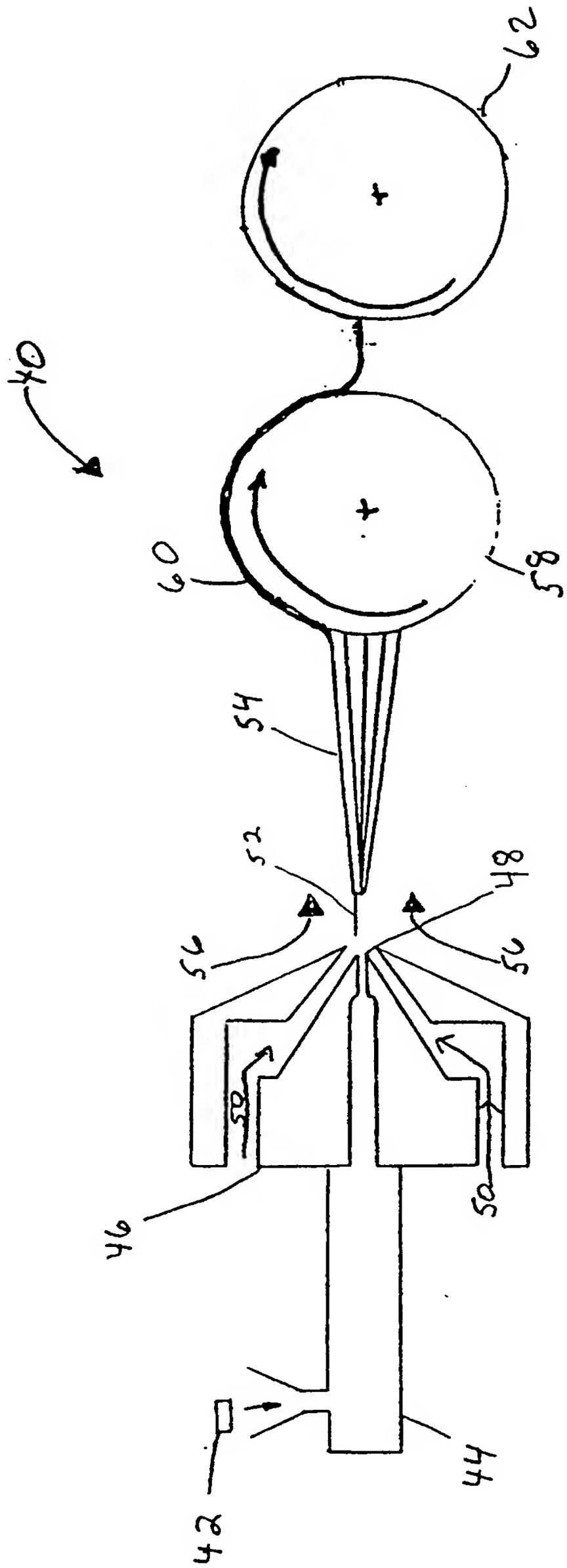


FIG. 2

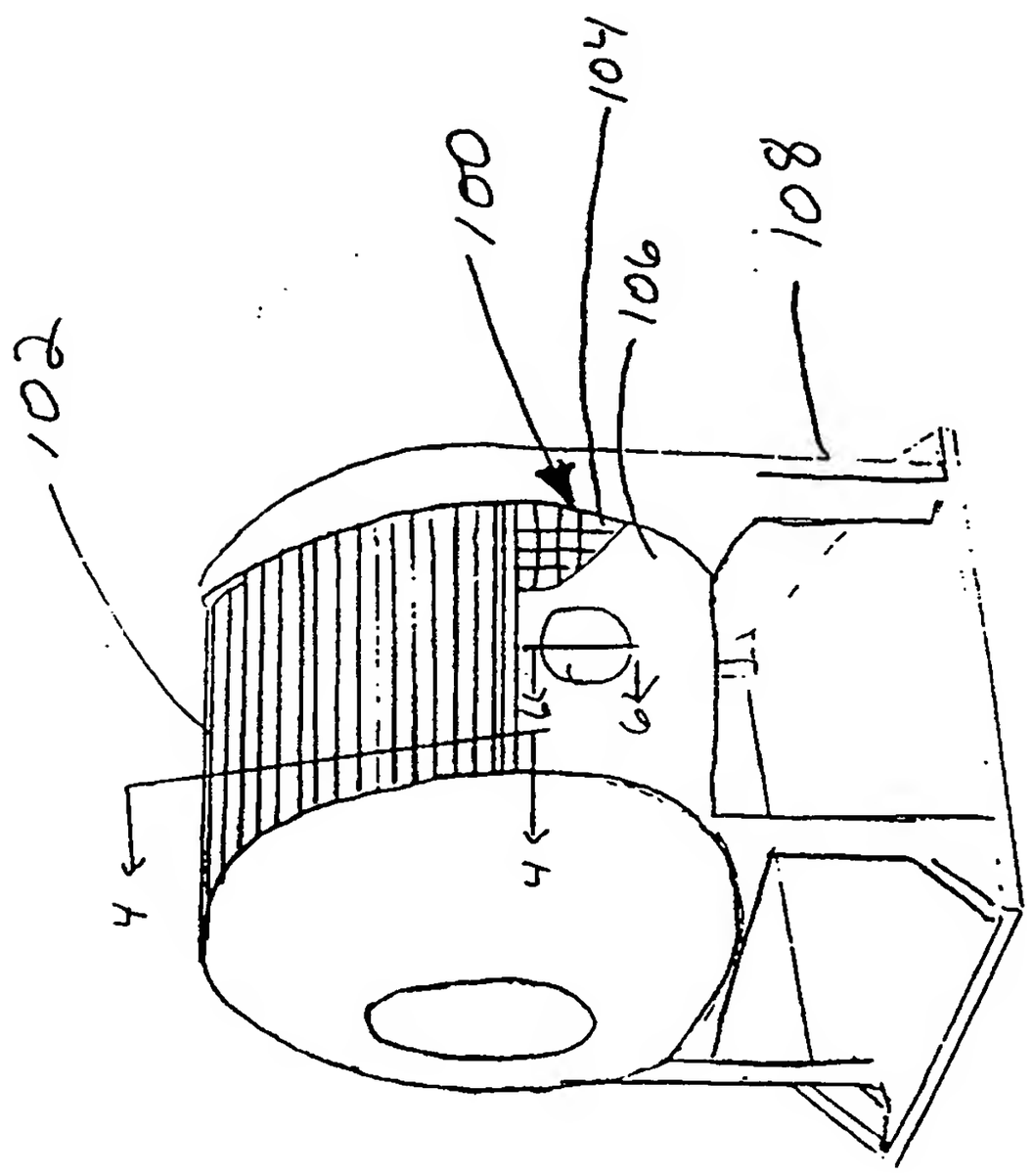


FIG.3A

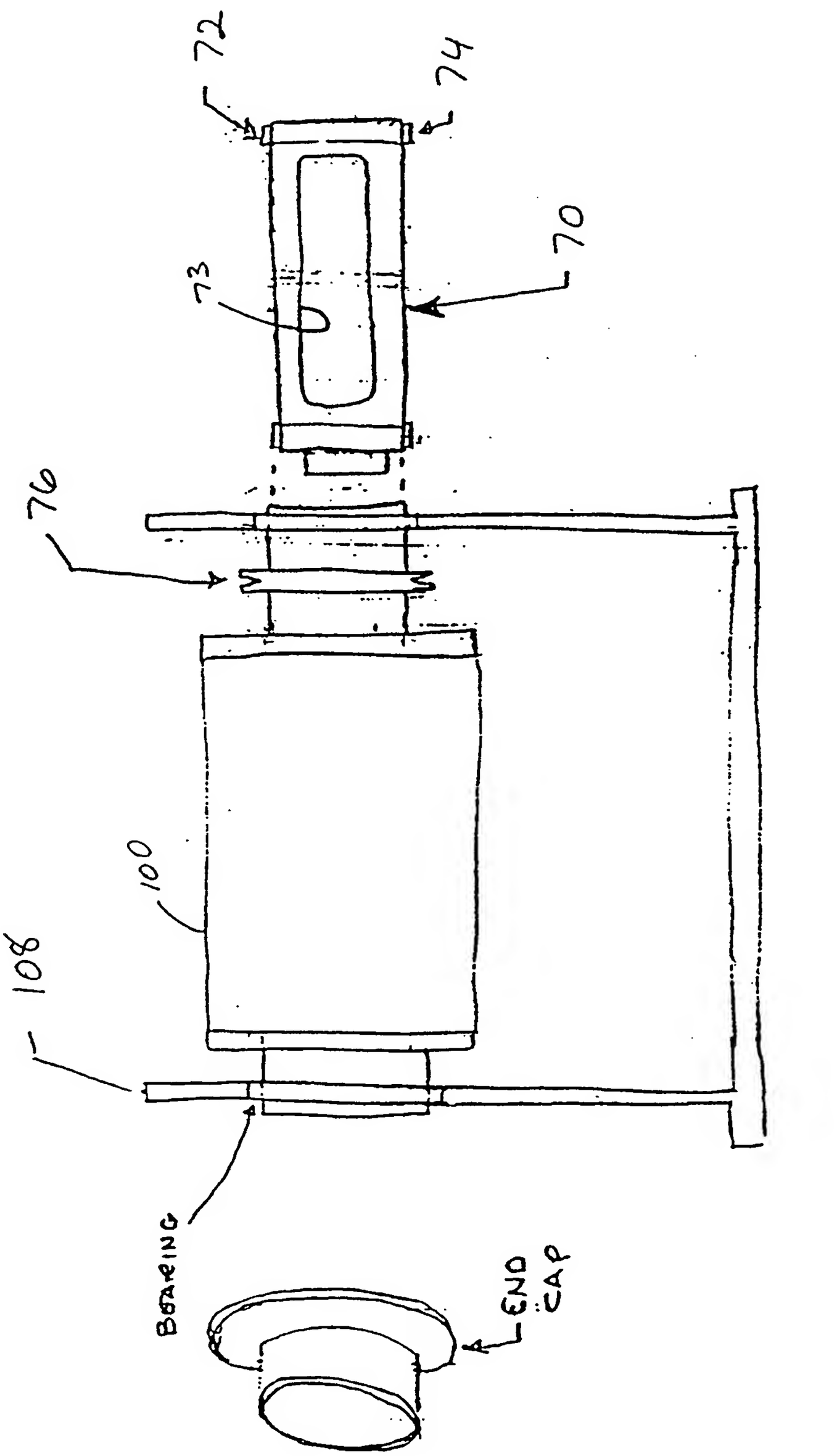


FIG. 3B

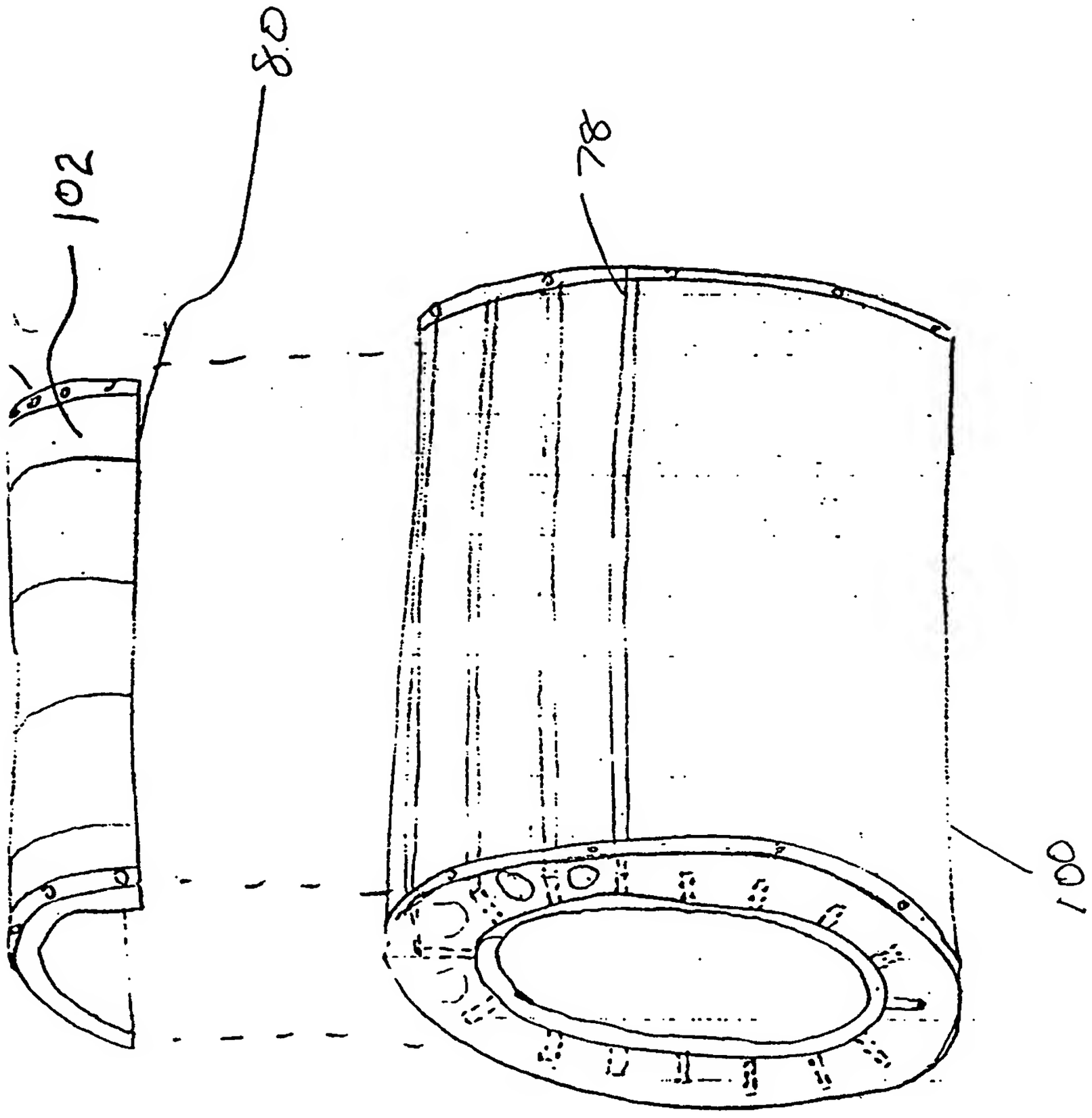


FIG 3C

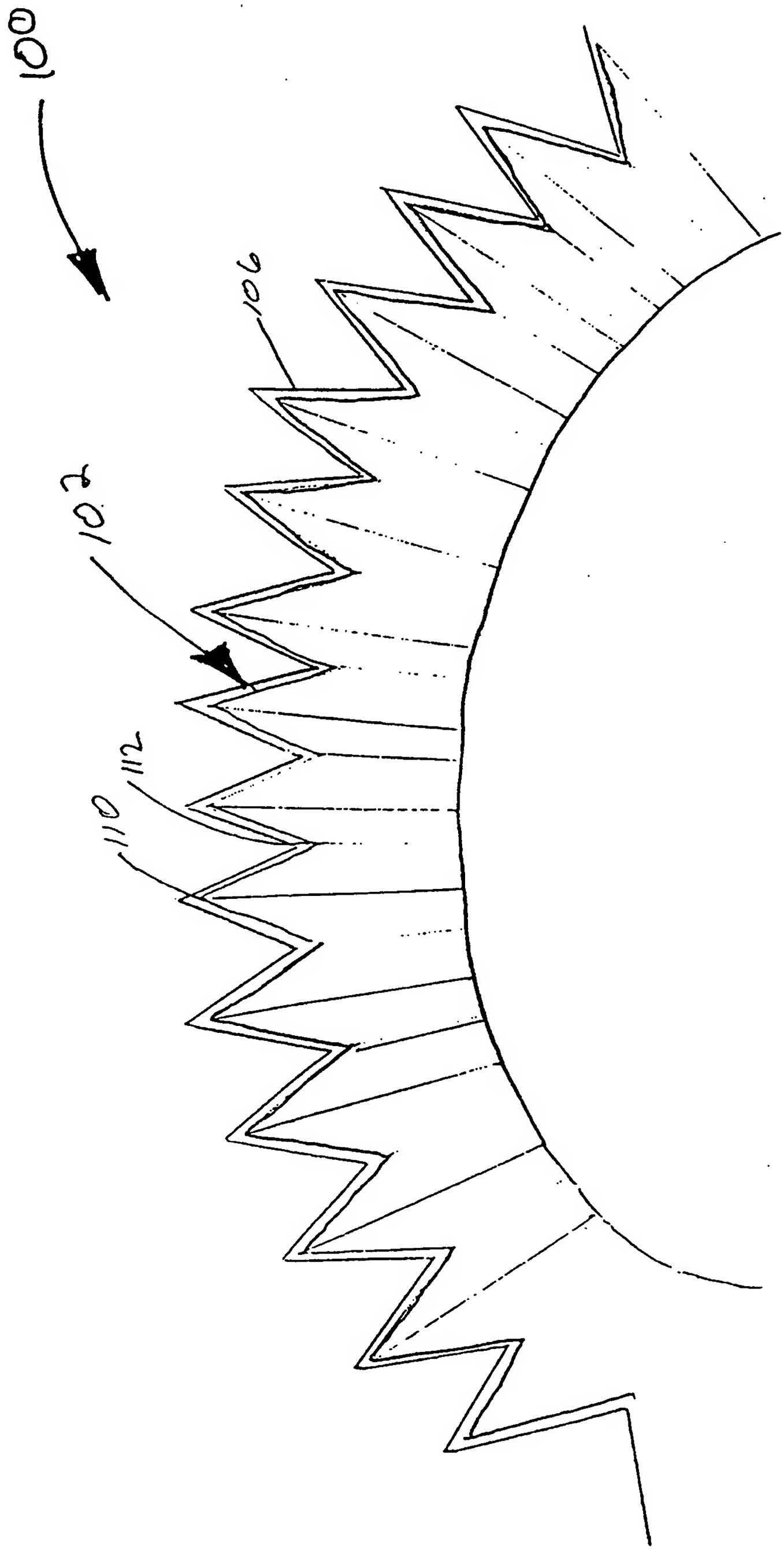


FIG. 4

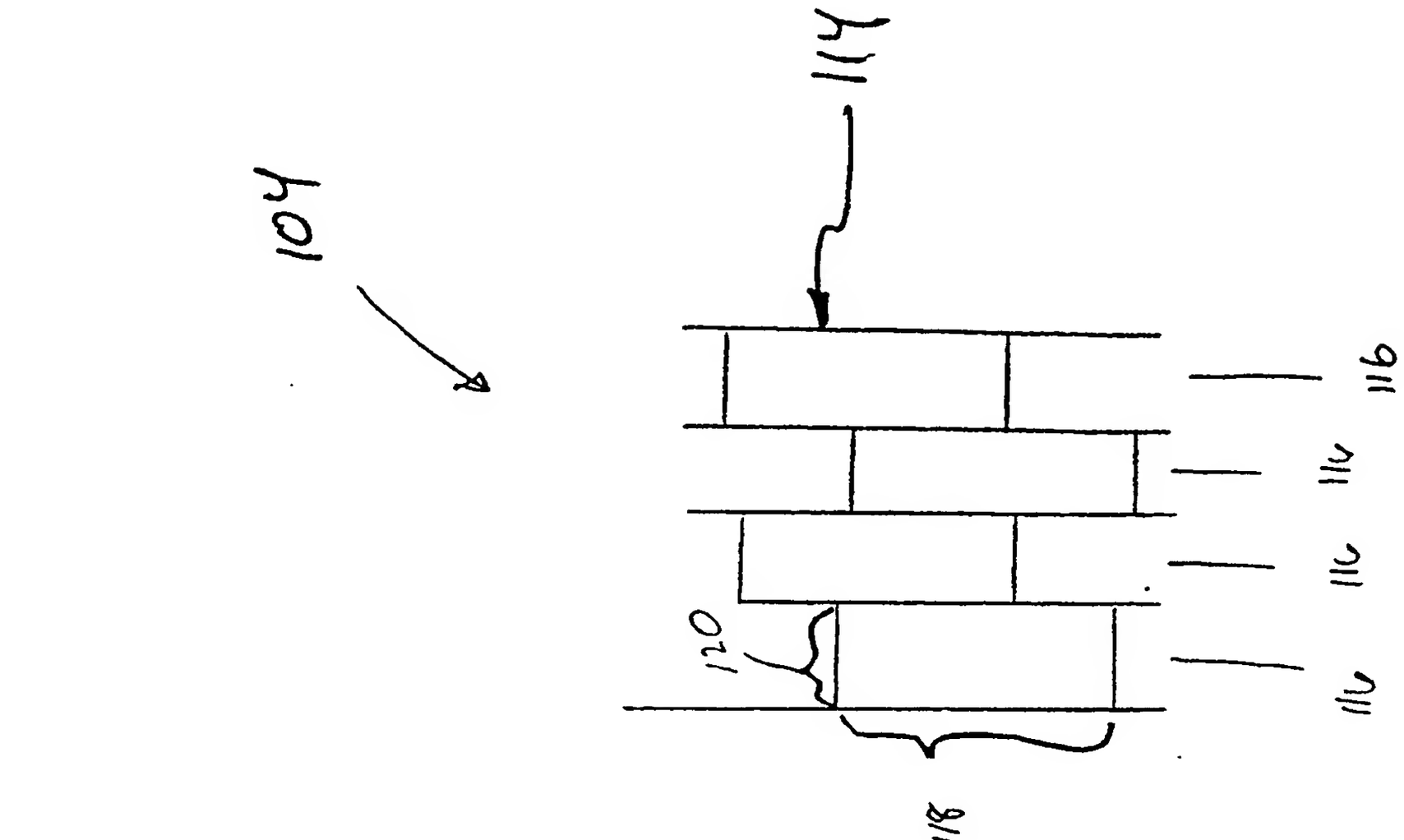


FIG. 5

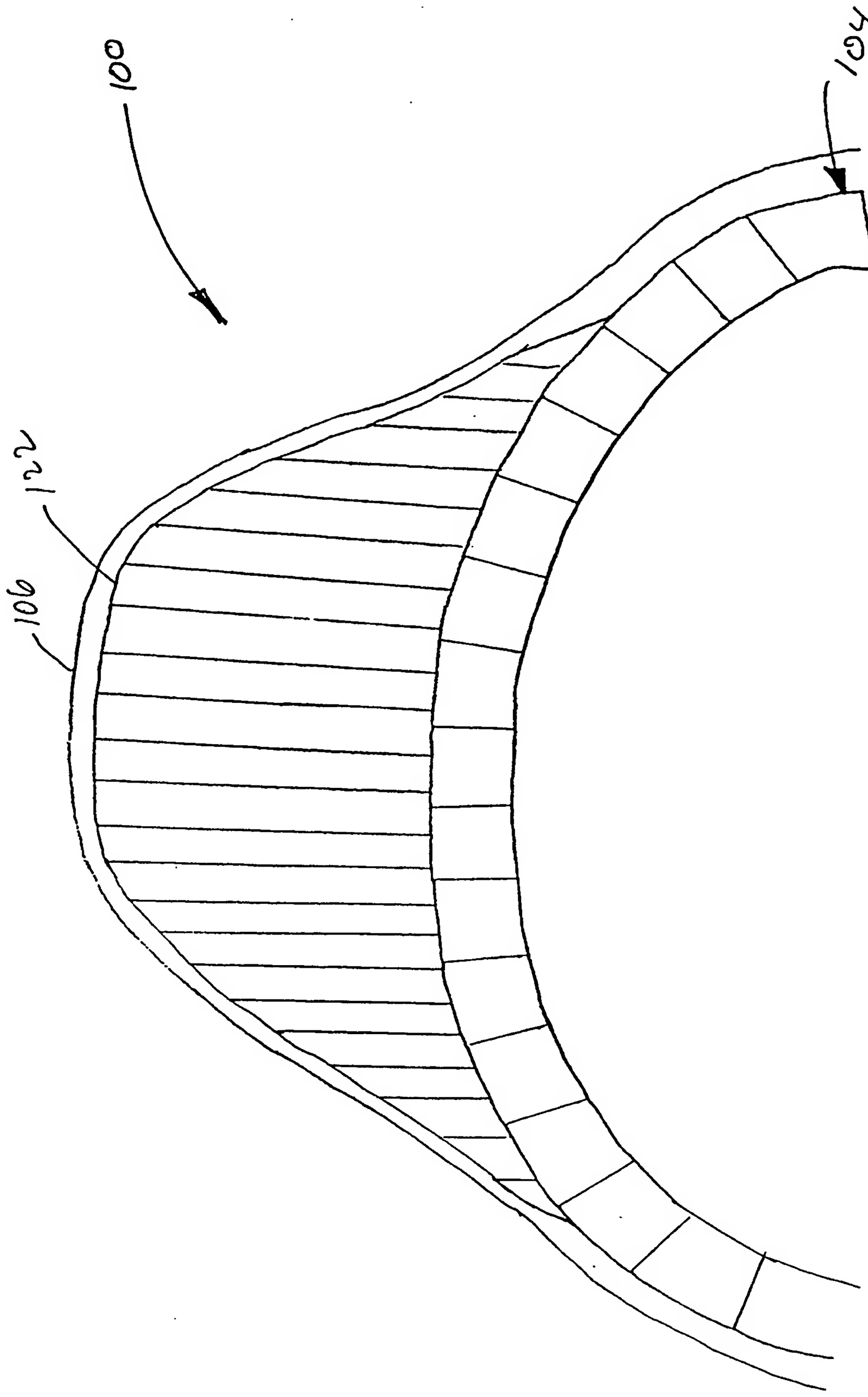
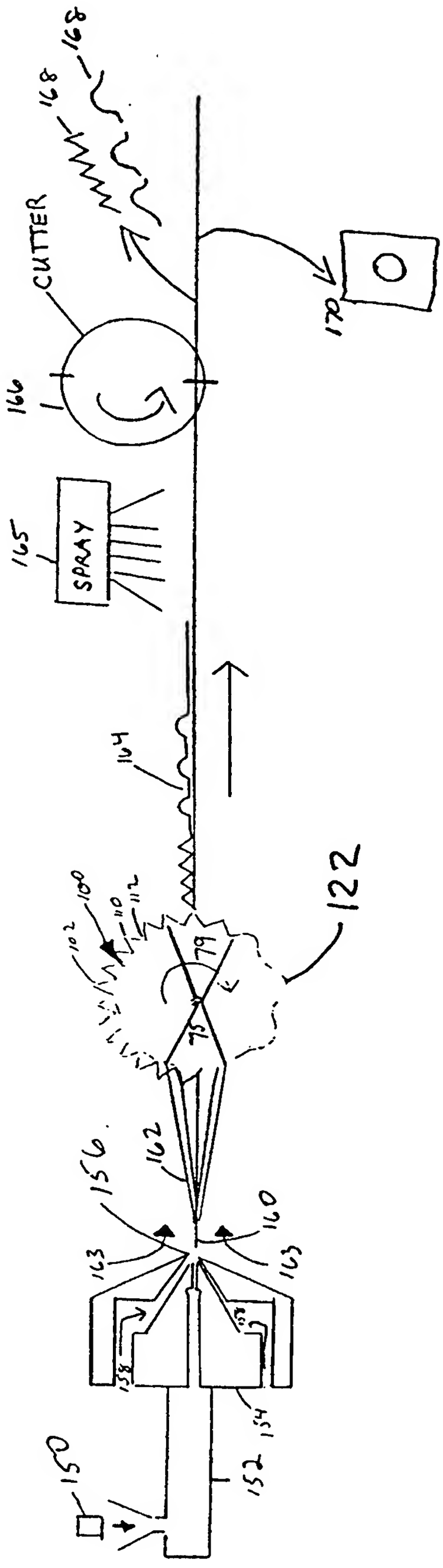


FIG. 6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SPRAY
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FIG. 7

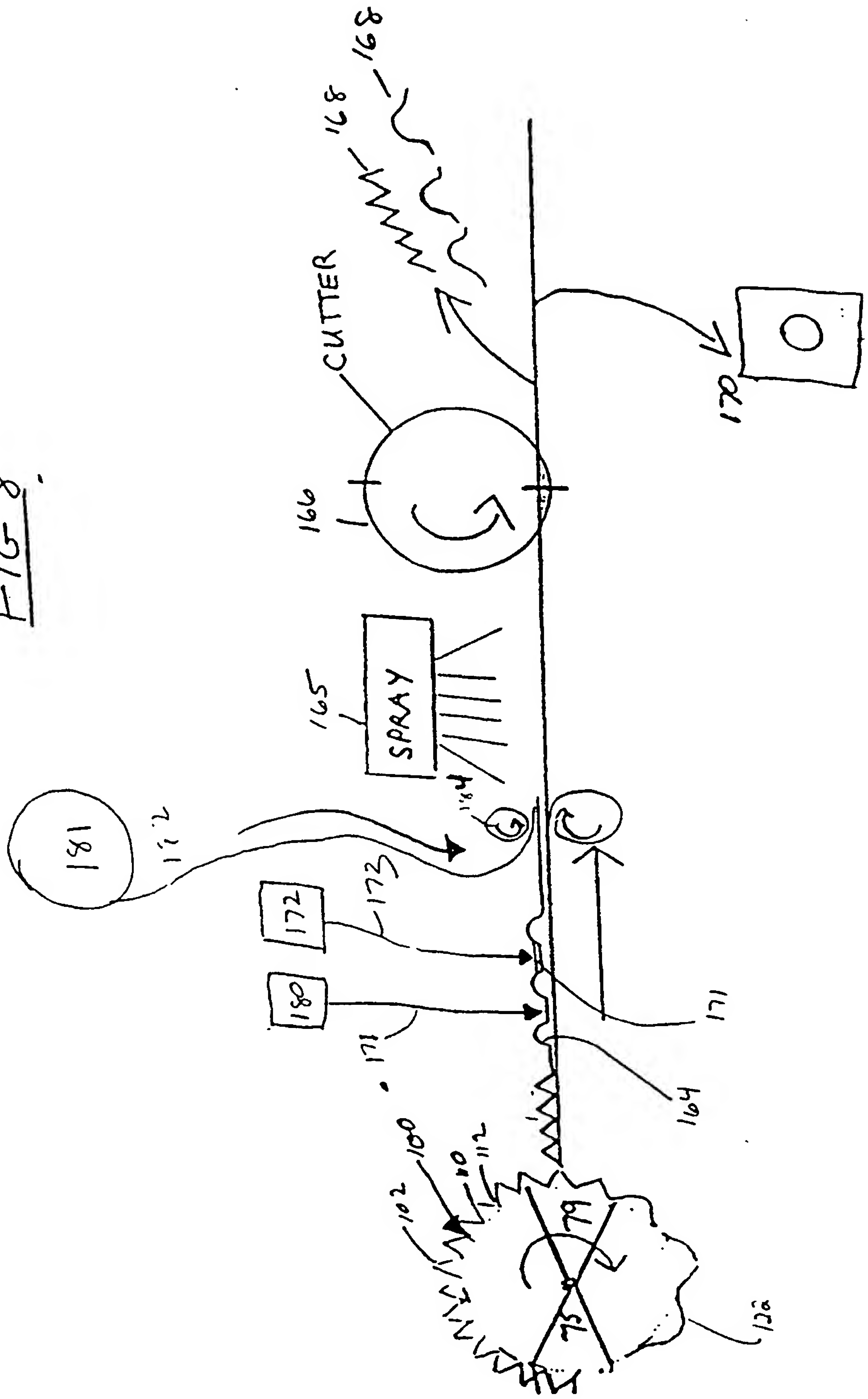
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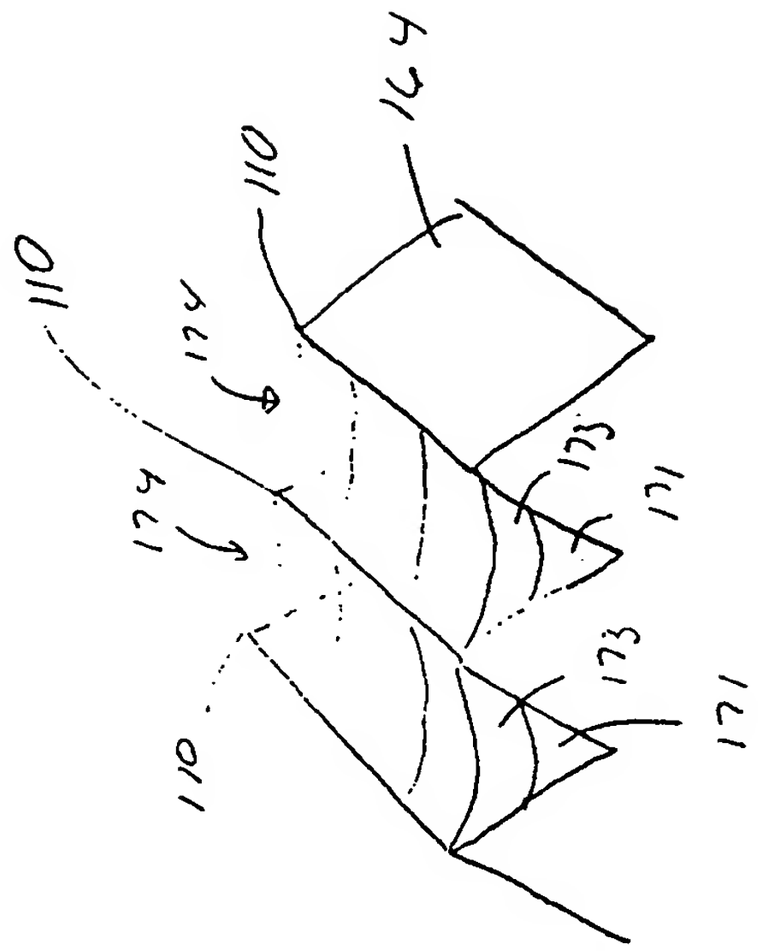
FIG 8

FIG. 9



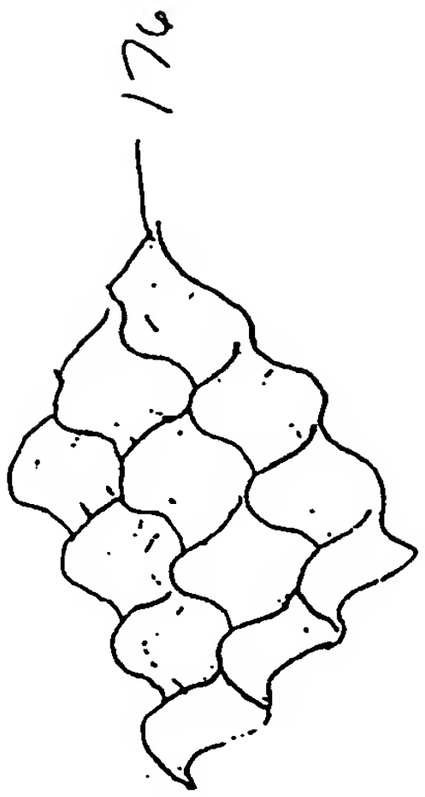


FIG. 10B

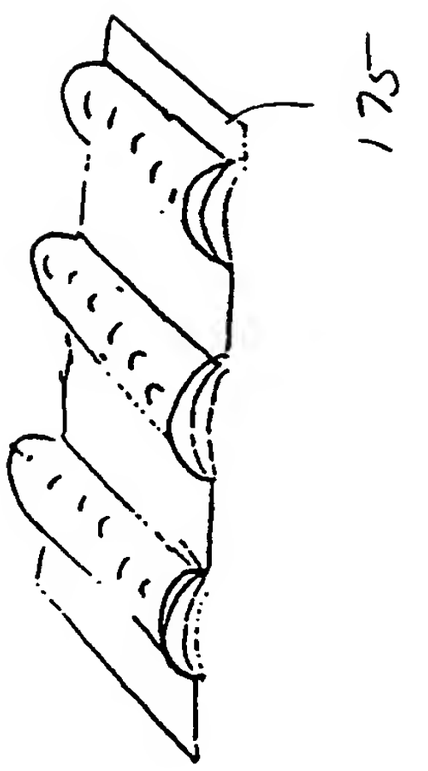


FIG. 10A

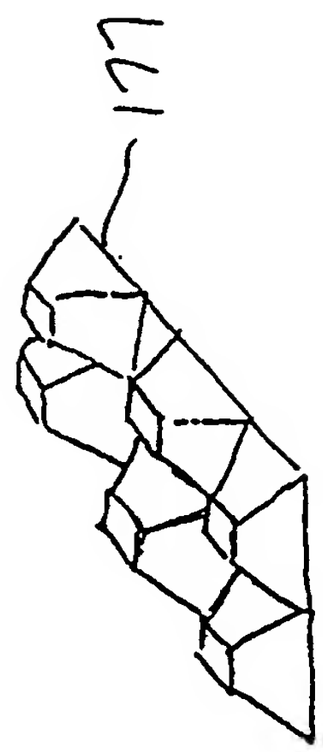


FIG. 10C

INTERNATIONAL SEARCH REPORT

Intern. ial Application No
PCT/US 99/27294

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 D04H3/16 D04H1/54 D04H1/72 D04H3/03 D04H3/07

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 D04H B65H B01D D21F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
19 April 2000	02/05/2000

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Intern al Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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(51) International Patent Classification 7 :
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A1

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(71) Applicant *(for all designated States except US)*: ELDIM, INC. [US/US]; 6 Centennial Drive, Peabody, MA 01960 (US).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: BONTAITES, George, J. [US/US]; 12 Tufts Street, Marblehead, MA 01945 (US).

(74) Agent: STAMOS, Christopher, W.; Testa, Hurwitz & Thibeault, LLP, High Street Tower, 125 High Street, Boston, MA 02110 (US).

(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

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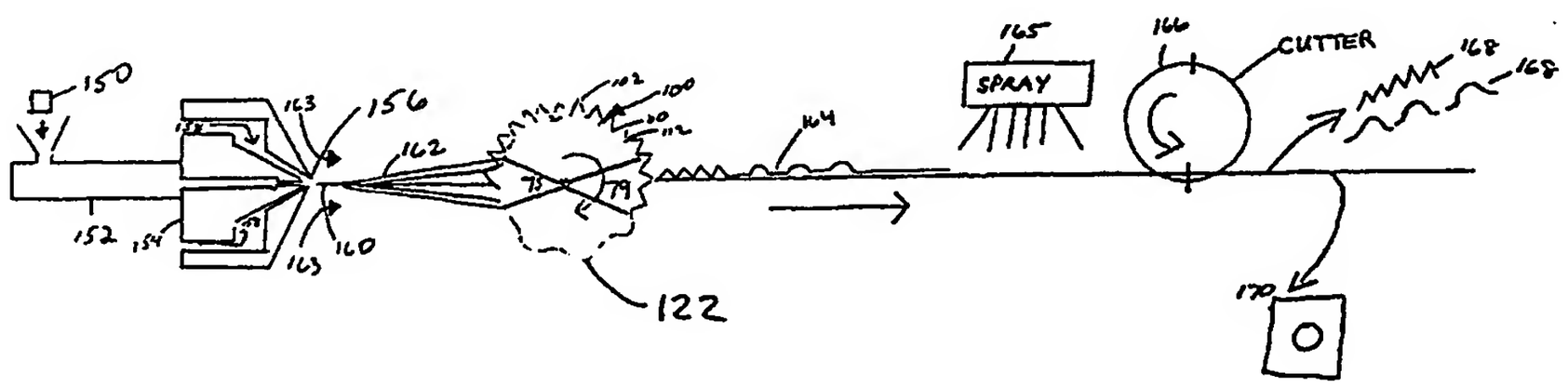
(54) Title: METHOD AND APPARATUS FOR MANUFACTURING NON–WOVEN ARTICLES



(57) Abstract

A method of manufacturing a non–woven material uses a contoured honeycomb drum with an outer microporous surface, more particularly with a contoured outer surface, for the manufacture of contoured non–woven fibrous materials. The method can use spunbonded, melt blown or electrostatic spun techniques for depositing solidify ing filaments on the microporous surface such that the non–woven material conforms to the contour of the drum, and then removing the non–woven material from the drum. The drum facilitates continous production of non–woven articles with three dimensional shapes such as surgical masks or pleated air filters. Additional materials may be added to the non–woven material to bridge between high points of a repeating three dimensional shape to obtain desired properties in a final product.

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AMENDED CLAIMS

[received by the International Bureau on 22 June 2000 (22.06.00);
original claims 8, 15, 17 and 18 amended;
original claim 14 and 16 cancelled; remaining claims unchanged (3 pages)]

1. A method of forming a non-woven article comprising the steps of:

providing a drum comprising:

a generally tubular honeycomb member having an outer surface forming a contour; and

a microporous layer covering at least a portion of the contour;

depositing solidifying filaments on the microporous layer to form a non-woven fibrous material substantially matching at least a portion of the contour; and

removing the fibrous material from the drum.

2. The method of claim 1 further comprising the step of providing negative pressure to at least a portion of the honeycomb member to conform the solidifying filaments to the contour.

3. The method of claim 1 further comprising the step of providing positive pressure to at least a portion of the honeycomb member to facilitate removing the fibrous material from the drum.

4. The method of claim 1 further comprising the step of post processing the non-woven material.

5. The method of claim 1 further comprising the step of trimming the article from the non-woven material.

6. The method of claim 1 further comprising the step of adding an additional material to the non-woven fibrous material.

7. The method of claim 6 further comprising the step of capturing the additional material with a covering.

8. A drum for forming non-woven articles, the drum comprising:

a generally tubular honeycomb member having an outer surface forming a contour, wherein the contour is formed in the honeycomb member; and

a microporous layer covering at least a portion of the contour.

9. The invention according to claim 8 further comprising:

a frame for rotatably supporting the drum; and

for rotating the drum.

10. The invention according to claim 8 further comprising:

a pipe located inside the drum, the pipe forming:

a vacuum port; and

an aperture in the pipe in fluidic communication with the vacuum port.

11. The invention according to claim 10, the pipe further forming

a pressure port; and

an aperture in the pipe in fluidic communication with the pressure port.

12. The invention according to claim 8 further comprising structural members for supporting the honeycomb member.

13. The invention according to claim 8 wherein the honeycomb member comprises a plurality of removable sectors.

14. Cancelled.

15. The invention according to claim 8 wherein a portion of the contour comprises alternating peaks and valleys.

16. Cancelled

17. The invention according to claim 8 wherein a portion of the contour comprises a three dimensional form.

AMENDED SHEET (ARTICLE 19)

BNSDOCID: <WO 0029656A1 IA>

18. The invention according to claim 17 wherein the three dimensional form comprises:
an additional honeycomb member and
a microporous layer covering at least a portion of the three dimensional form.

19. An article produced in accordance with the method of claim 1.

20. An article produced in accordance with the method of claim 6.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

CORRECTED VERSION

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(71) Applicant *(for all designated States except US)*: **ELDIM, INC.** [US/US]; 6 Centennial Drive, Peabody, MA 01960 (US).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **BONTAITES, George, J.** [US/US]; 12 Tufts Street, Marblehead, MA 01945 (US).

(74) Agent: **STAMOS, Christopher, W.**; Testa, Hurwitz & Thiebeault, L.L.P., High Street Tower, 125 High Street, Boston, MA 02110 (US).

(81) Designated States *(national)*: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

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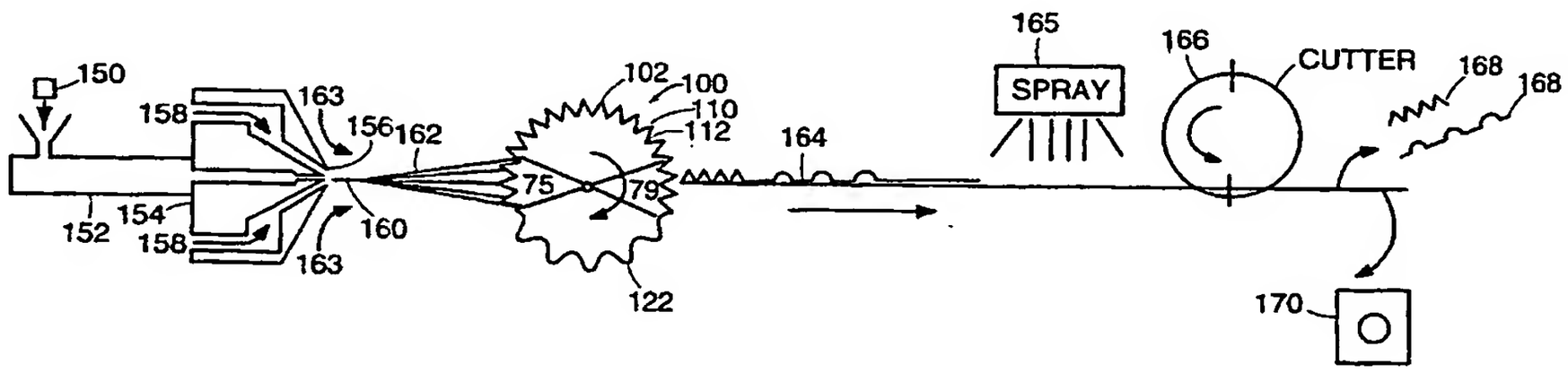
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHOD AND APPARATUS FOR MANUFACTURING NON-WOVEN ARTICLES



(57) Abstract: A method of manufacturing a non-woven material uses a contoured honeycomb drum with an outer microporous surface, more particularly with a contoured outer surface, for the manufacture of contoured non-woven fibrous materials. The method can use spunbonded, melt blown or electrostatic spun techniques for depositing solidify ing filaments on the microporous surface such that the non-woven material conforms to the contour of the drum, and then removing the non-woven material from the drum. The drum facilitates continous production of non-woven articles with three dimensional shapes such as surgical masks or pleated air filters. Additional materials may be added to the non-woven material to bridge between high points of a repeating three dimensional shape to obtain desired properties in a final product.

WO 00/29656 A1

METHOD AND APPARATUS FOR MANUFACTURING NON-WOVEN ARTICLES

Related Applications

This application claims priority to U.S. Patent Application Serial No. 09/193,582, filed November 17, 1998, and U.S. Provisional Patent Application Serial No. 60/149,270, filed August 17, 1999, the disclosures of which are incorporated herein by reference in their entirety.

Field of the Invention

This invention relates to a method of using a honeycomb drum with an outer microporous surface. more particularly with a contoured outer surface, for the manufacture of contoured non-woven fibrous materials.

Background of the Invention

Non-woven articles are used in applications that require materials to be air permeable. Some applications of non-woven materials are surgical masks and filter membranes. Since many applications that use non-woven material require disposable articles, the non-woven articles should be easily manufacturable and low cost. Some methods of manufacturing non-woven materials are spunbonded, melt blown processes and electro spinning of nano-fibers.

FIG. 1 illustrates the spunbonded process 10 for manufacturing non-woven materials. Thermoplastic fiber forming polymer 12 is placed in an extruder 14 and passed through a linear or circular spinneret 16. The extruded liquid polymer streams 18 are rapidly cooled and attenuated by air and/or mechanical drafting rollers 20 to form desired diameter solidifying filaments 22. The solidifying filaments 22 are then laid down on a first conveyor belt 24 to form a web 26. The web 26 is then bonded by rollers 28 to form a spunbonded web 30. The spunbonded web 30 is then transferred by a second conveyer belt 32 and then to a windup 34. The spunbonded process is an integrated one step process which begins with a polymer resin and ends with a finished fabric.

FIG. 2 illustrates the melt blown process 40 for manufacturing non-woven materials. Thermoplastic forming polymer 42 is placed in an extruder 44 and is then passed through a linear die 46 containing about twenty to forty small orifices 48 per inch of die 46 width. Convergent streams of hot air 50 rapidly attenuate the extruded liquid polymer streams 52 to form solidifying filaments 54. The solidifying filaments 54 subsequently get blown by high velocity air 56 onto a

take-up screen 58, thus forming a melt blown web 60. The web is then transferred to a windup 62. U.S. Patent Number 4,380,570 entitled "Apparatus and Process for Melt-Blowing a Fiberforming Thermoplastic Polymer and Product Produced Thereby" describes the melt blown process and is incorporated herein by reference in its entirety.

While non-woven materials can be manufactured by either the spunbonded or melt blown process there are difficulties associated with each process. For example, the newly manufactured non-woven material (e.g. melt blown web 60) tends to stick to the take-up screen 58. Further, the processes produce sheet material. Accordingly, to manufacture non-woven materials into three dimensional shapes, e.g. surgical masks and pleated filters, some form of post-processing is required.

Summary of the Invention

The present invention relates to a method for manufacturing non-woven articles. In one embodiment, the method includes providing a drum made of a tubular honeycomb member that forms an outer contour which is surrounded by a microporous layer, depositing solidifying filaments on the microporous layer to form a non-woven material that matches the contour of the drum, and removing the non-woven material from the drum.

In another embodiment of the present invention, the method for manufacturing non-woven articles further adds the step of providing a negative pressure to a part of the drum to conform the solidifying filaments to the contour of the drum.

In another embodiment of the present invention, the method of manufacturing a non-woven article also includes the additional step of providing a positive pressure to a portion of the drum to facilitate removing the non-woven material from the drum.

In another embodiment of the present invention, the method of manufacturing a non-woven article also includes the additional step of treating the non-woven material with additional supplements such as a stain repellent or coloring.

Another embodiment of the present invention, relates to a drum with a generally tubular honeycomb member that has an outer surface forming a contour, where the contour is covered with a microporous layer, for the manufacture of a non-woven materials.

In another embodiment of the present invention, the drum can have a negative pressure applied to a portion of the drum in order to help the non-woven materials conform to the contoured outer surface of the drum.

In another embodiment of the present invention, the drum can have a positive pressure applied to a portion of the drum in order to help remove the non-woven materials from the drum.

In another embodiment of the present invention, the drum can be made up of panels with different contoured outer surfaces to generate non-woven materials of different shapes from the same drum.

In another embodiment of the present invention, one or more additional materials may be added to the non-woven material to bridge a contoured surface or otherwise change desired properties of a final product.

Brief Description of the Drawings

This invention is pointed out with particularity in the appended claims. The above and further advantages of this invention may be better understood by referring to the following description, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic of a spunbonded process for manufacturing non-woven materials.

FIG. 2 is a schematic of a melt blown process for manufacturing non-woven materials.

FIG. 3A is a perspective view of an embodiment of the drum of the current invention, illustrating a contoured honeycomb tube with an outer microporous surface.

FIG. 3B is a partially exploded side view of the drum illustrating the mounting structure, vacuum apparatus, and V-belt drive groove.

FIG. 3C is a partially exploded perspective view of the drum structure.

FIG. 4 is a partial cross-sectional view of the drum taken along line 4-4 in Fig. 3A illustrating a pleated surface.

FIG. 5 is a partial radial view of the drum illustrating the honeycomb mesh.

FIG. 6 is a cross-sectional view of the drum taken along line 6-6 in Fig. 3A illustrating a contoured outer surface having a three dimensional surface.

FIG. 7 is a schematic of a process of the current invention for the manufacture of non-woven materials that substantially match the contoured outer surface of the drum.

FIG. 8 is a schematic of a process of the current invention for the post processing of non-woven materials after a three dimensional contour has been formed.

FIG. 9 is a schematic perspective view illustrating a first material and a second material bridging a three dimensional contour.

FIGS. 10A-10C are schematic perspective views illustrating three embodiments of three dimensional shapes that can be formed in a non-woven material by a process of the current invention.

Detailed Description of the Invention

Referring to FIG. 3A, shown is a drum 100 having a contoured outer surface 102 constructed in accordance with the teachings of the present invention. The contoured outer surface 102 may take many different shapes and forms. As shown, the drum 100 is made of a tubular honeycomb member 104 that is surrounded by a microporous layer 106. The microporous layer 106 is tack welded to the tubular honeycomb member 104 and may be finely electroetched stainless steel having numerous holes on the order of 0.010 inches (0.25 mm) in diameter, such that the microporous layer 106 is about fifty percent open. A frame 108 rotatably supports the drum 100. The material for the tubular honeycomb member 104 can be, but is not limited to, stainless steel.

Referring to FIG. 3B, the drum 100 is supported by the frame 108 or frames, so that the drum 100 can be rotated as the solidifying filaments are continuously applied. FIG. 3B also shows a pipe 70 with a vacuum port 72 and a bearing surface 74. The pipe 70 is located in the center of the drum 100. The pipe 70 also has a slot 73 that is in communication with the vacuum port 72 to draw a negative pressure 75 through a sector of the drum 100 to conform the solidifying filaments to the contour. See FIG. 7. Also shown is V-belt drive 76 which can be used to rotate the drum 100 by any conventional source known to those skilled in the art, such as a variable speed motor.

Referring to FIG. 3C, the drum 100 includes inner support bars 78 which are located throughout the drum 100. The inner support bars 78 provide stiffness to the drum 100 and allow a negative pressure 75 or positive pressure 79 to be provided to a portion of the drum 100, as shown in FIG. 7. FIG. 3C also shows that the drum 100 includes a plurality of panels 80 that can attached to the drum 100 by a variety of means (e.g. fasteners or clips). The panels 80 can be made to form any desired contoured outer surface 102.

Referring to FIG. 4, shown is a partial cross-sectional view of one embodiment of the drum 100 of the present invention. The drum 100 has a contoured outer surface 102 that has the shape of alternating peaks 110 and valleys 112. The contoured outer surface 102 is covered by

the microporous layer 106. As will be further shown, the contoured outer surface 102 with alternating peaks 110 and valleys 112 can be used to form pleated-shaped non-woven articles.

Referring to FIG. 5, shown is a partial radial view of the drum 100 illustrating a rectangular mesh 114 of tubular honeycomb member 104. The mesh 114 consists of alternating multiple rows of mesh holes 116, where each row is offset from the previous row. Each mesh hole has a length 118 and width 120. In one embodiment the mesh hole length 118 is about 0.5 inches (1.3 cm) and the width 120 is about 0.25 inches (0.64 cm). By using a rectangular mesh 114, the honeycomb member 104 can be readily formed into a circular contour.

Referring to FIG. 6, shown is another partial cross-sectional view of the drum 100 illustrating a three dimensional form 122 that is attached (e.g. tack-welded) to the drum 100. The three dimensional form 122 also has honeycomb construction and can be formed by. but not limited to, electrical discharge machining. The three dimensional form 122 is also covered by the microporous layer 106. As will be further shown, the three dimensional form 122 can be used to make, for example, a surgical mask shaped article.

FIG. 7, shows one process for manufacturing contoured non-woven articles. Thermoplastic forming polymer 150 is placed in an extruder 152 and passed through a linear die 154 containing about twenty to forty or more small orifices 156 per inch of die 154 width. Convergent streams of hot air 158 rapidly attenuate the extruded liquid polymer 160 to form solidifying filaments 162. The solidifying filaments 162 subsequently get blown by high velocity air 163 onto the contoured outer surface 102 of drum 100. Note that the method illustrated in FIG. 7 for generating the solidifying filaments 162 is a melt blown process, but a spunbonded process, or any other method for generating the solidifying filaments 162 can be used, such as electrospinning of nano-fibers using an electrostatic spun technique. Melt blown process equipment is available from Biax Fiberfilm Corporation located in Wisconsin.

The drum 100, which is rotating, has a contoured outer surface 102, which can have a combination of shapes, for example, alternating peaks 110 and valleys 112 or a series of three dimensional forms 122. Once the solidifying filaments 162 are deposited on the drum 100, a vacuum or negative pressure 75 can be applied to a portion of the drum 100 to conform the solidifying filaments 162 to the contoured outer surface 102, to prepare closely matching contoured non-woven materials 164.

After the contoured non-woven materials 164 are formed, the rotating drum 100 rotates to a point where the contoured non-woven materials 164 are removed from the drum 100. Positive pressure 79 can optionally be applied through a portion of the drum 100 to facilitate removing the contoured non-woven materials 164 from the drum 100. Once off the drum 100, the contoured non-woven material 164 can be post processed in a variety of post processing operations, for examples by application of a spray 165. The treatment can consist of adding various supplements such as flame retardents, stain repellents, colored dyes, and the like, or to change the shape, feel, texture, or appearance of the contoured non-woven material 164.

FIG. 8 is an expanded view of additional optional post processing performed on the contoured non-woven material 164. In addition to the treatment operations discussed above, a first material 171 may be added to the contoured non-woven material 164 in order to achieve desired properties in a final product 168. The first material 171 may be a non-woven material or any other material, based on properties required in the final product 168. For example, some materials that can be used for the first material 171 are absorbent substances or charcoal or other filter materials known to those skilled in the art. The first material 171 may be selected based on desired material properties such as pore size, fiber diameter and length, basis weight, and density.

FIG. 8 shows a process step 180 for adding the first material 171 to the contoured non-woven material 164. The process 180 for adding the first material 171 to the contoured non-woven material 164 may be a spunbonded process or a melt blown process for non-woven materials. Alternatively, loose fill or pre-formed sheet goods, with or without an adhesive treatment, can be deposited on the non-woven material 164. If the first material 171 is a material other than a non-woven material, a person skilled in the art can choose the appropriate method for manufacturing the desired material. Additional process 172 can add a second different material 173 on top of the first material 171. The same considerations used to select the first material 171 can be used to select the second material 173.

A covering material 182 from a source 181 may be placed over the contoured non-woven material 164. The covering material 182 captures or retains the first material 171 and the optional second material 173 within the contoured non-woven material 164. Some materials that may be used for the covering material 182 are organic fibers, inorganic fibers, and polymers, which can be in the form of woven or non-woven sheet goods, films, and the like, and which may or may not be porous. The covering material 182 may be adhered or bonded to the

contoured non-woven material 164 by a variety of processes 184 known to those skilled in the art, such as a pair of rollers, a heated die, etc. to seal and/or laminate the layers. Additional layers of materials and coverings may be applied, as desired.

FIG. 9 illustrates the presence of the first material 171 and the second material 173 in the valleys of a pleated contoured non-woven material 164. The first material 171 and the second material 173 effectively bridge 174 the peaks 110 in the pleated material 164. The bridge 174 may be made up of just the first material 171, a combination of the first material 171 and the second material 173, or a plurality of different desired materials. The bridge 174 may bridge or partially or fully fill any three dimensional contour.

The process of FIG. 8 results in a wide variety of articles which can be used in a variety of applications. One embodiment resulting from the process of FIG. 8 consists of a non-woven material 164, where the first material 171 added is a carbon filtration material and a covering material is applied overall. Another embodiment consists of a non-woven material 164, where the material added results in a varying gradient filter article. The varying gradient filter article has multiple filter layers, each layer can have its own filter pore size. Each layer in the varying gradient filter article can trap different particle sizes. In addition, another embodiment of the process of FIG. 8 consists of a non-woven material 164, where the first material 171 added can be a high loft material, so that the resultant article can be used for absorption of oil or other liquid. Other materials can be selected by a person skilled in the art, based on the particular application and performance sought

FIGS. 10A-10C show additional three dimensional contours which can be manufactured by the process in accordance with the invention, such as half tube 175, multinodal 176, and pyramidal or frustoconical 177 contours. Other contours, both regular and irregular, will be apparent to those skilled in the art based on the teachings herein.

Referring back to FIG. 7, after any post processing has been completed, the contoured non-woven material 164 may pass through a cutter 166, to cut the contoured non-woven material 164 into the desired article or final product 168. The cutter 166 may be a die, water jet, laser, or any other apparatus capable of trimming to the desired contour. Any waste 170 after the cutting operation can either be disposed of or recycled. Accordingly, non-woven contoured articles such as wipes, filters, face masks, sorbent products, insulation, clothing, and the like can be rapidly produced from polypropylene, polyester, or other materials in a continuous process at low cost.

Variations, modifications, and other implementations of what is described herein will occur to those of ordinary skill in the art without departing from the spirit and the scope of the invention as claimed. Accordingly, the invention is to be defined not by the preceding illustrative description, but instead by the following claims.

What is claimed is:

1. A method of forming a non-woven article comprising the steps of:

providing a drum comprising:

a generally tubular honeycomb member having an outer surface forming a contour; and

a microporous layer covering at least a portion of the contour;

depositing solidifying filaments on the microporous layer to form a non-woven fibrous material substantially matching at least a portion of the contour; and

removing the fibrous material from the drum.

2. The method of claim 1 further comprising the step of providing negative pressure to at least a portion of the honeycomb member to conform the solidifying filaments to the contour.

3. The method of claim 1 further comprising the step of providing positive pressure to at least a portion of the honeycomb member to facilitate removing the fibrous material from the drum.

4. The method of claim 1 further comprising the step of post processing the non-woven material.

5. The method of claim 1 further comprising the step of trimming the article from the non-woven material.

6. The method of claim 1 further comprising the step of adding an additional material to the non-woven fibrous material.

7. The method of claim 6 further comprising the step of capturing the additional material with a covering.

8. A drum for forming non-woven articles, the drum comprising:

a generally tubular honeycomb member having an outer surface forming a contour; and

a microporous layer covering at least a portion of the contour.

9. The invention according to claim 8 further comprising:
a frame for rotatably supporting the drum; and
for rotating the drum.

10. The invention according to claim 8 further comprising:
a pipe located inside the drum, the pipe forming:
a vacuum port; and
an aperture in the pipe in fluidic communication with the vacuum port.

11. The invention according to claim 10, the pipe further forming
a pressure port; and
an aperture in the pipe in fluidic communication with the pressure port.

12. The invention according to claim 8 further comprising structural members for supporting the honeycomb member.

13. The invention according to claim 8 wherein the honeycomb member comprises a plurality of removable sectors.

14. The invention according to claim 8 wherein the contour is formed in the honeycomb member.

15. The invention according to claim 14 wherein a portion of the contour comprises alternating peaks and valleys.

16. The invention according to claim 8 wherein the contour is mounted to the honeycomb member.

17. The invention according to claim 16 wherein a portion of the contour comprises a three dimensional form.

18. The invention according to claim 17 wherein three dimensional form comprises:
an additional honeycomb member and
a microporous layer covering at least a portion of the three dimensional form.

19. An article produced in accordance with the method of claim 1.

20. An article produced in accordance with the method of claim 6.

AMENDED CLAIMS

[received by the International Bureau on 22 June 2000 (22.06.00);
original claims 8, 15, 17 and 18 amended;
original claim 14 and 16 cancelled; remaining claims unchanged (3 pages)]

1. A method of forming a non-woven article comprising the steps of:

providing a drum comprising:

a generally tubular honeycomb member having an outer surface forming a contour; and

a microporous layer covering at least a portion of the contour;

depositing solidifying filaments on the microporous layer to form a non-woven fibrous material substantially matching at least a portion of the contour; and

removing the fibrous material from the drum.

2. The method of claim 1 further comprising the step of providing negative pressure to at least a portion of the honeycomb member to conform the solidifying filaments to the contour.

3. The method of claim 1 further comprising the step of providing positive pressure to at least a portion of the honeycomb member to facilitate removing the fibrous material from the drum.

4. The method of claim 1 further comprising the step of post processing the non-woven material.

5. The method of claim 1 further comprising the step of trimming the article from the non-woven material.

6. The method of claim 1 further comprising the step of adding an additional material to the non-woven fibrous material.

7. The method of claim 6 further comprising the step of capturing the additional material with a covering.

8. A drum for forming non-woven articles, the drum comprising:

a generally tubular honeycomb member having an outer surface forming a contour, wherein the contour is formed in the honeycomb member; and

a microporous layer covering at least a portion of the contour.

9. The invention according to claim 8 further comprising:

a frame for rotatably supporting the drum; and

for rotating the drum.

10. The invention according to claim 8 further comprising:

a pipe located inside the drum, the pipe forming:

a vacuum port; and

an aperture in the pipe in fluidic communication with the vacuum port.

11. The invention according to claim 10, the pipe further forming

a pressure port; and

an aperture in the pipe in fluidic communication with the pressure port.

12. The invention according to claim 8 further comprising structural members for supporting the honeycomb member.

13. The invention according to claim 8 wherein the honeycomb member comprises a plurality of removable sectors.

14. Cancelled.

15. The invention according to claim 8 wherein a portion of the contour comprises alternating peaks and valleys.

16. Cancelled

17. The invention according to claim 8 wherein a portion of the contour comprises a three dimensional form.

18. The invention according to claim 17 wherein the three dimensional form comprises:

an additional honeycomb member and

a microporous layer covering at least a portion of the three dimensional form.

19. An article produced in accordance with the method of claim 1.

20. An article produced in accordance with the method of claim 6.

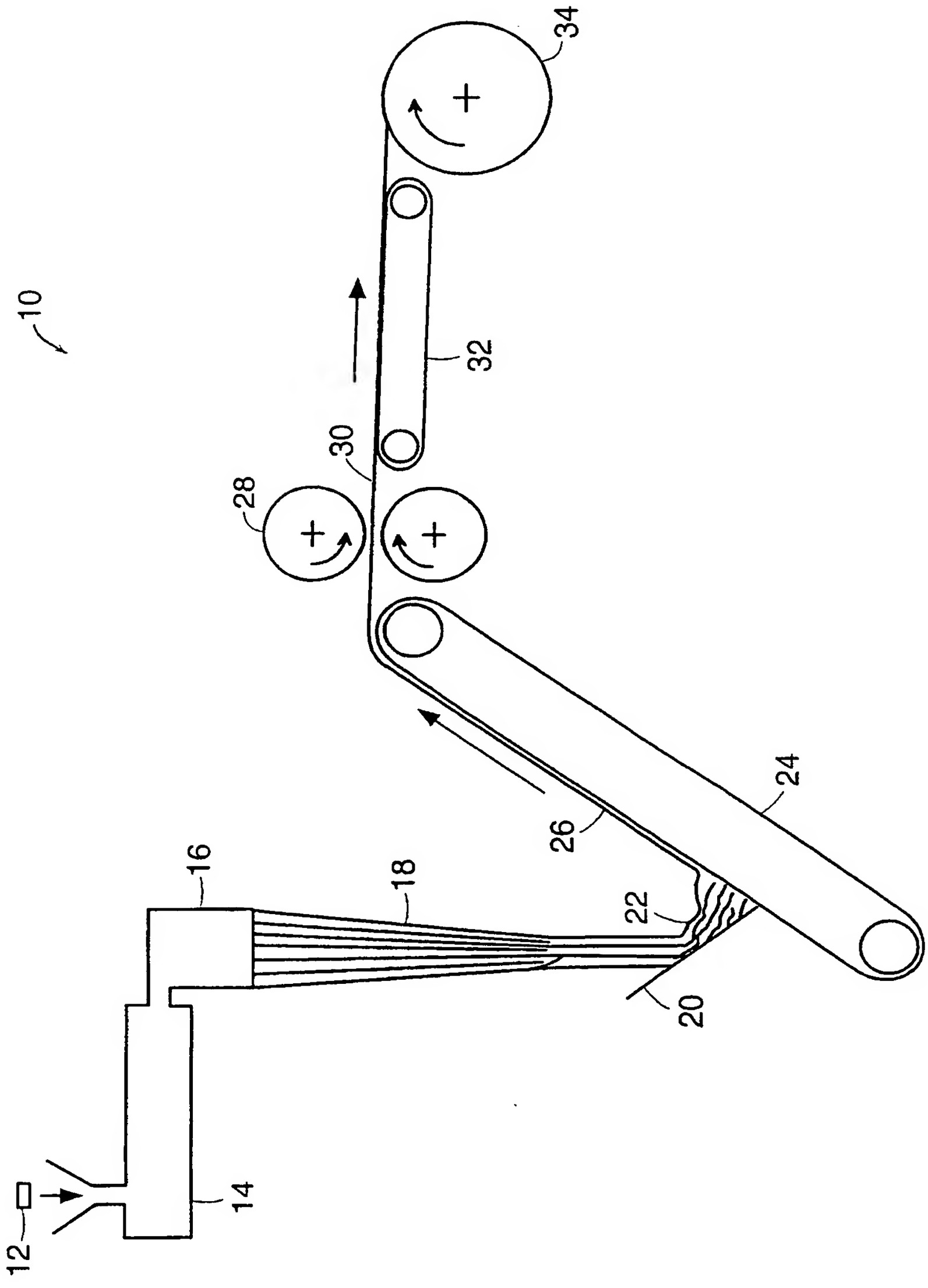


FIG. 1

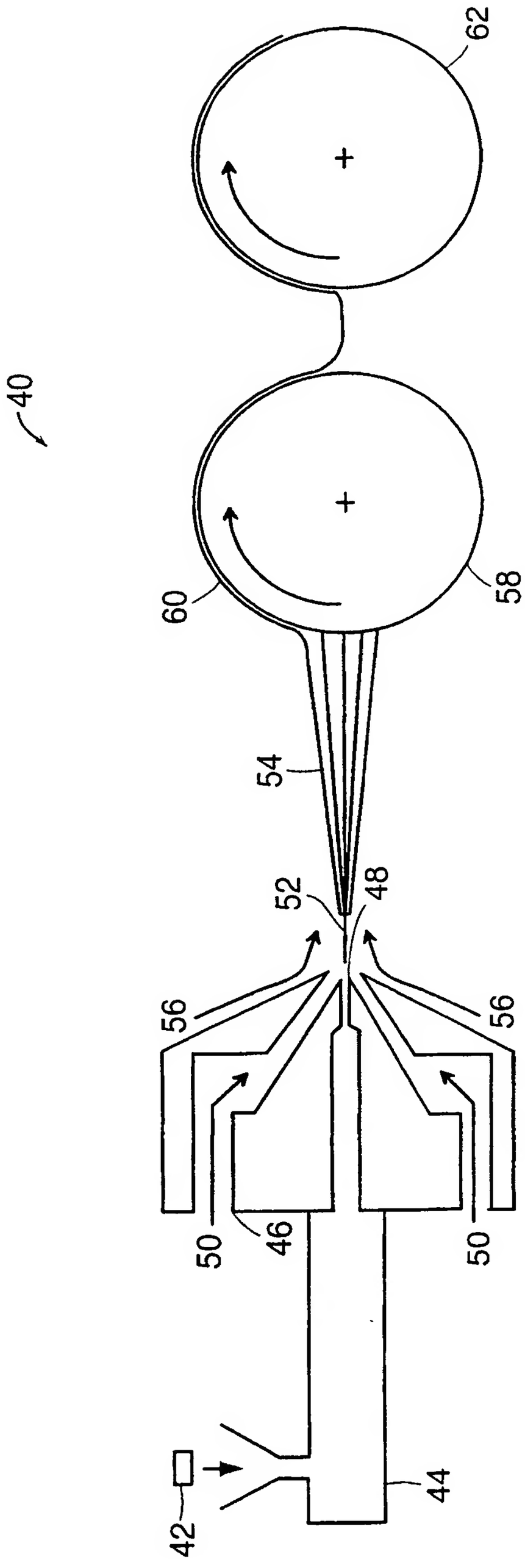


FIG. 2

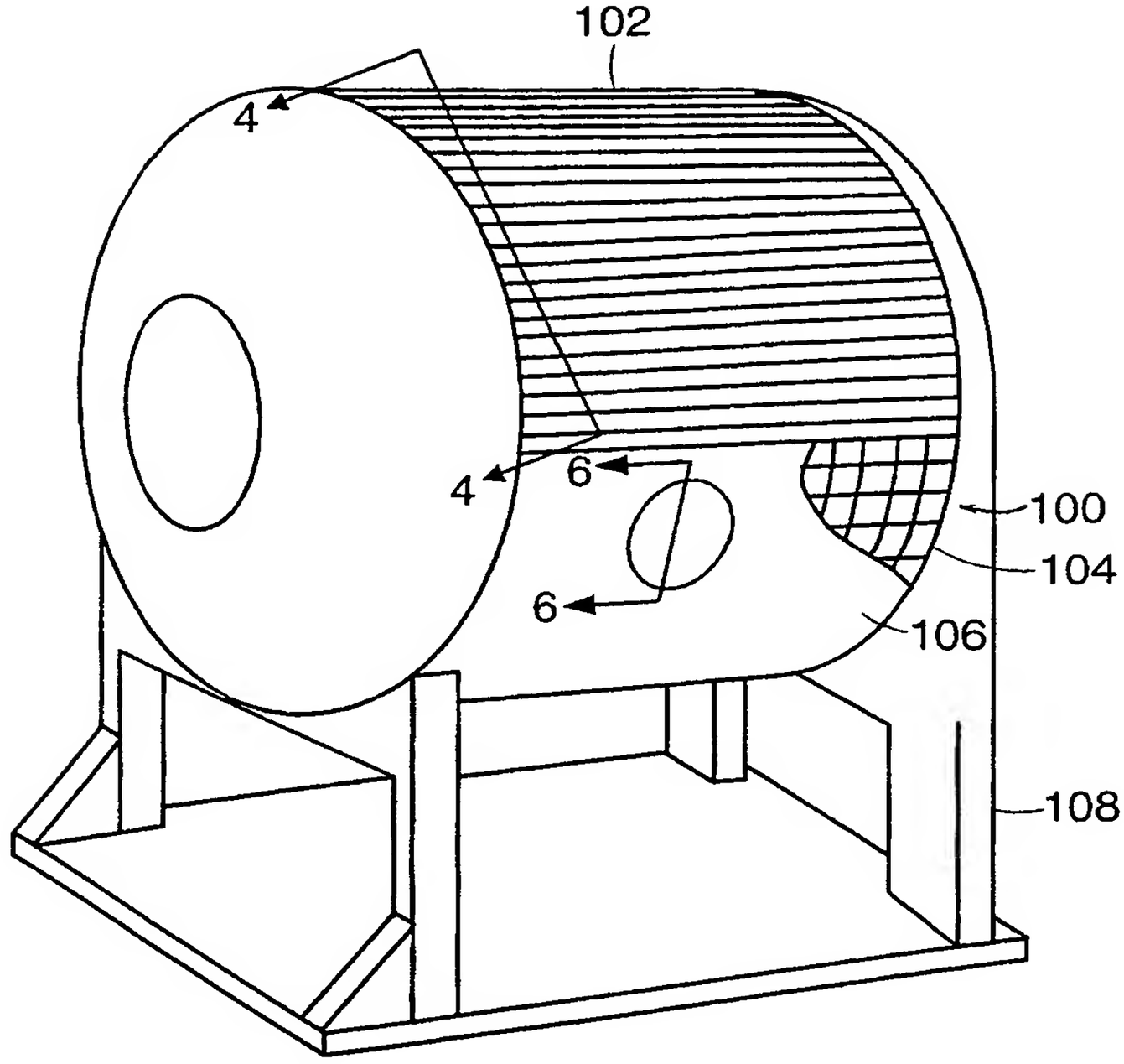


FIG. 3A

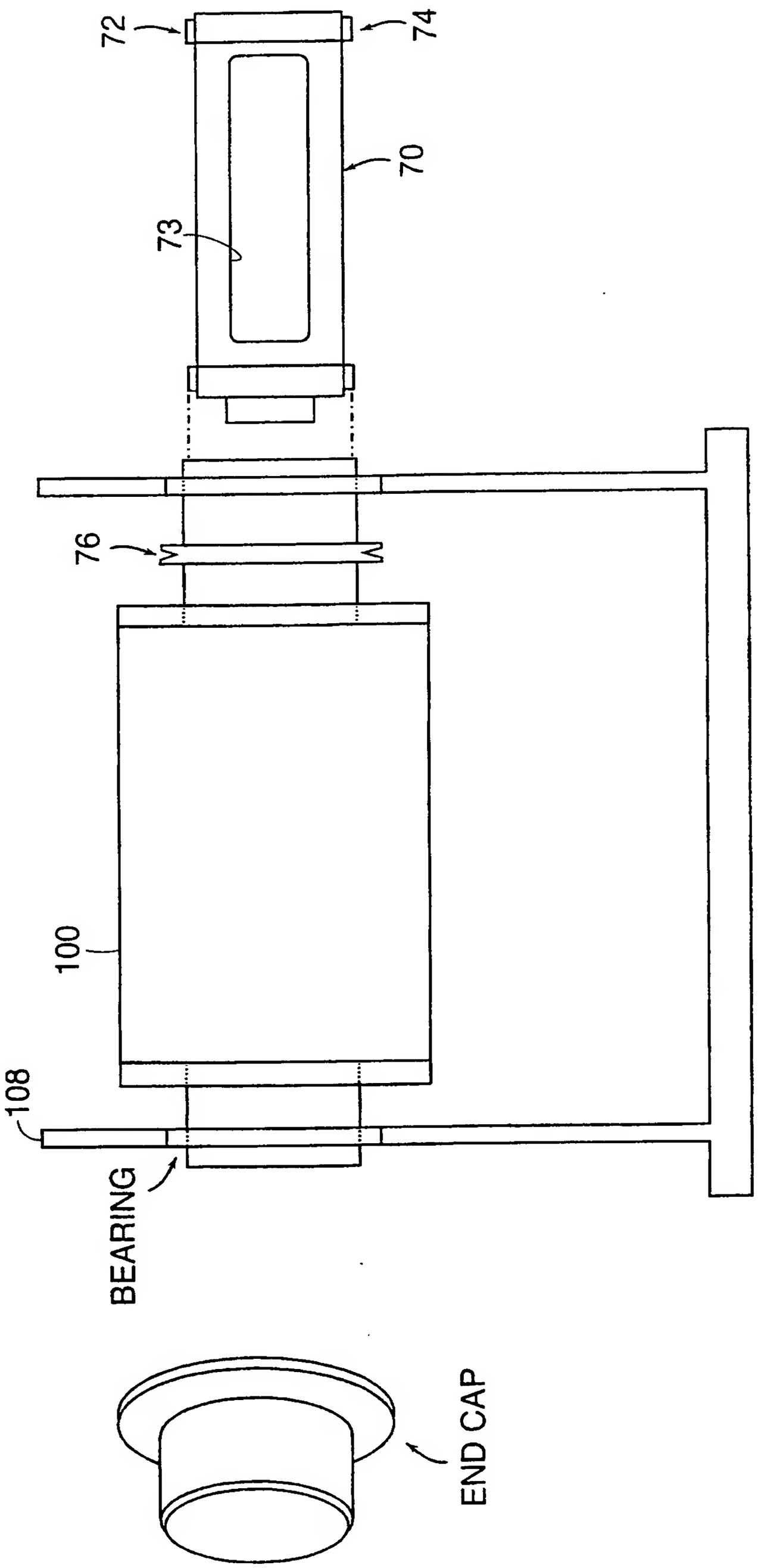


FIG. 3B

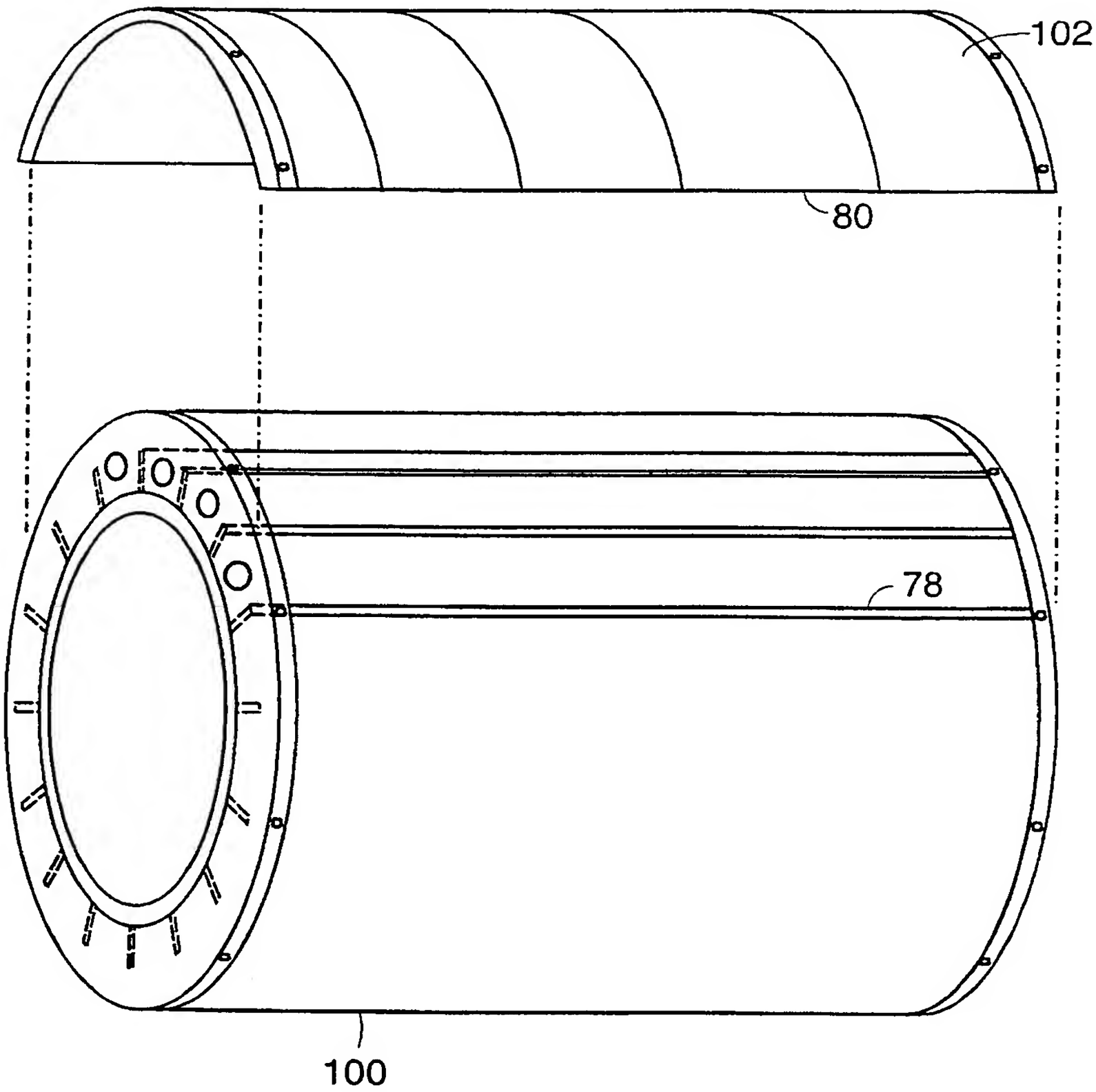


FIG. 3C

BNSDOCID: <WO 0029656A1 IB>

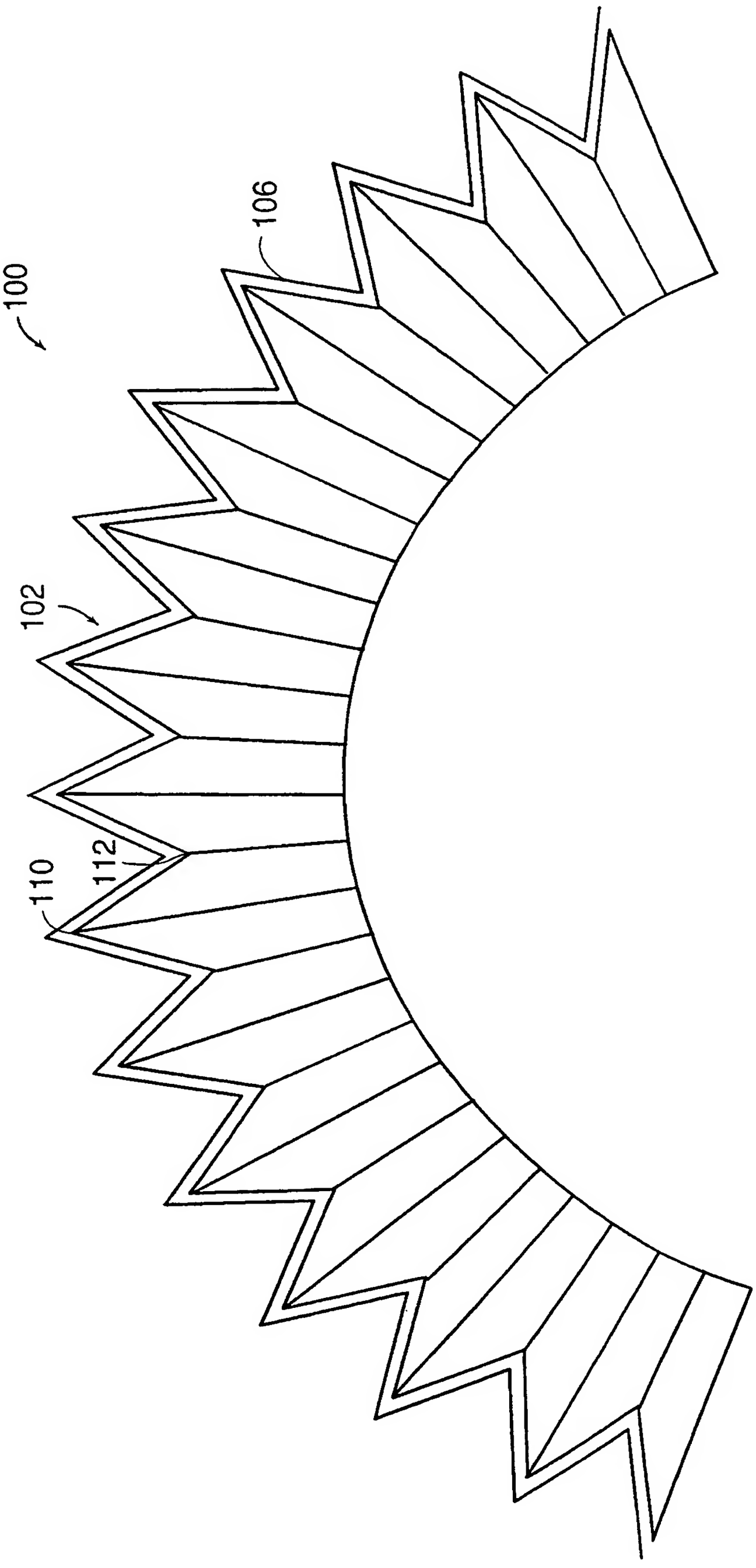


FIG. 4

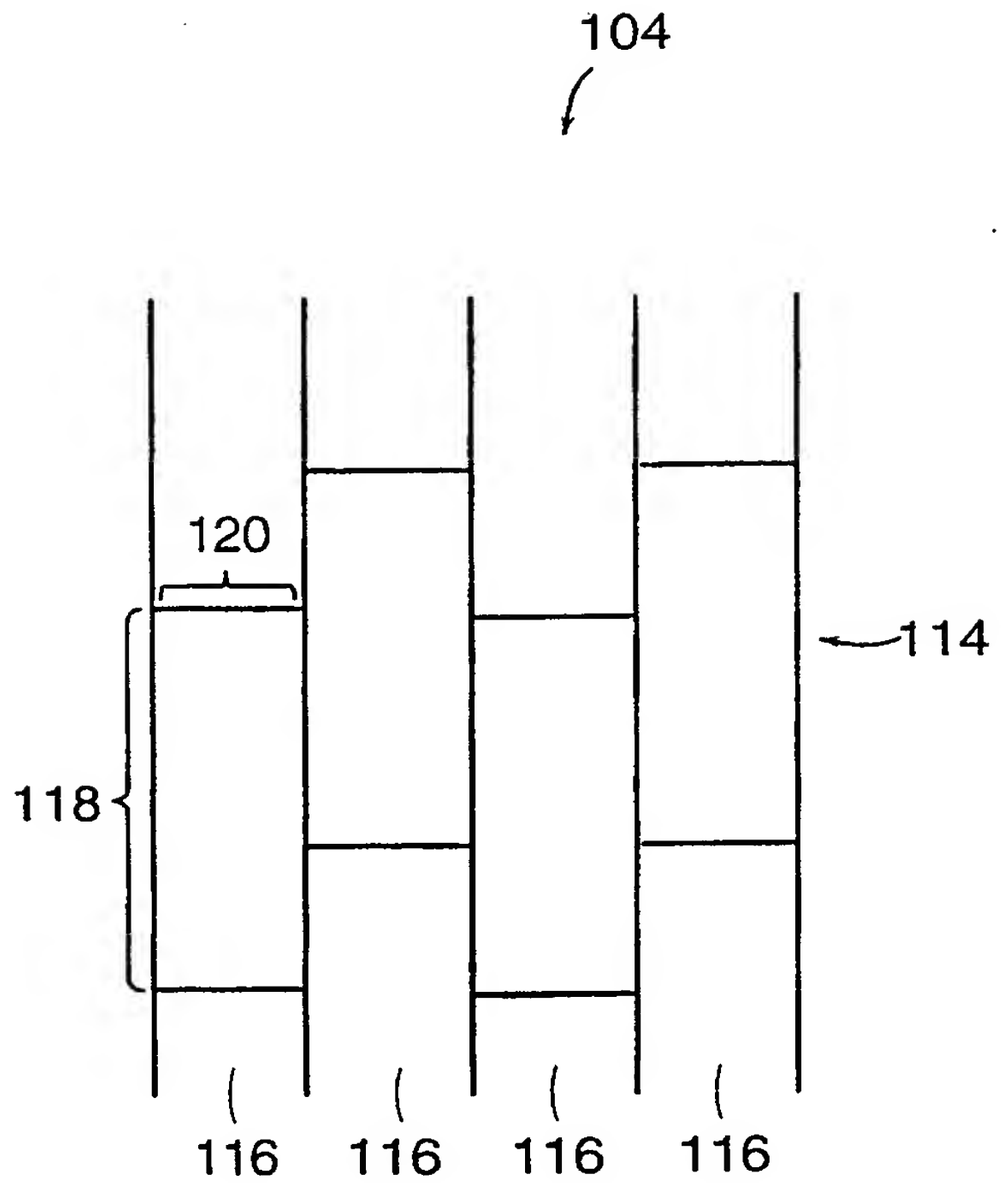


FIG. 5

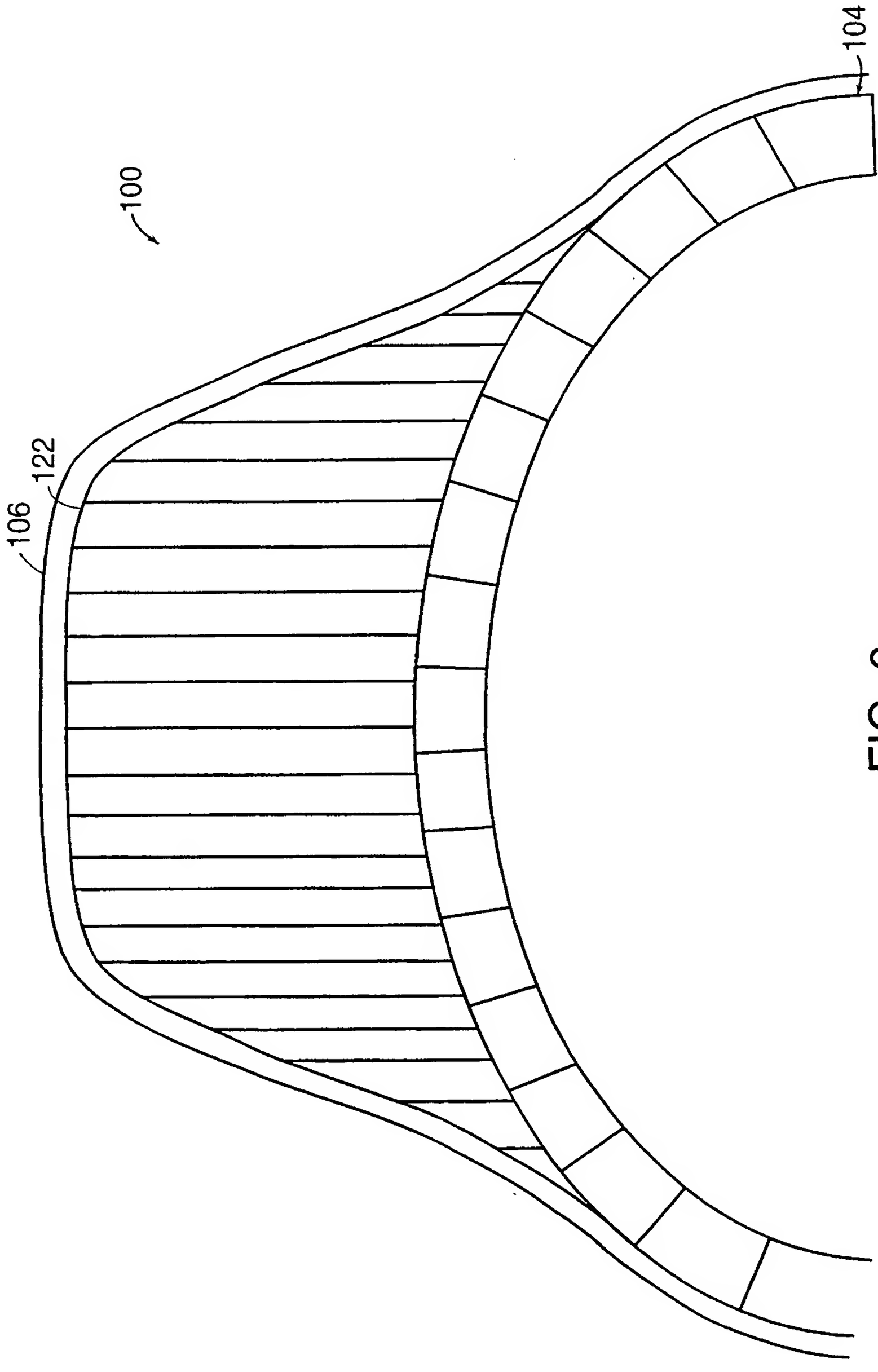


FIG. 6

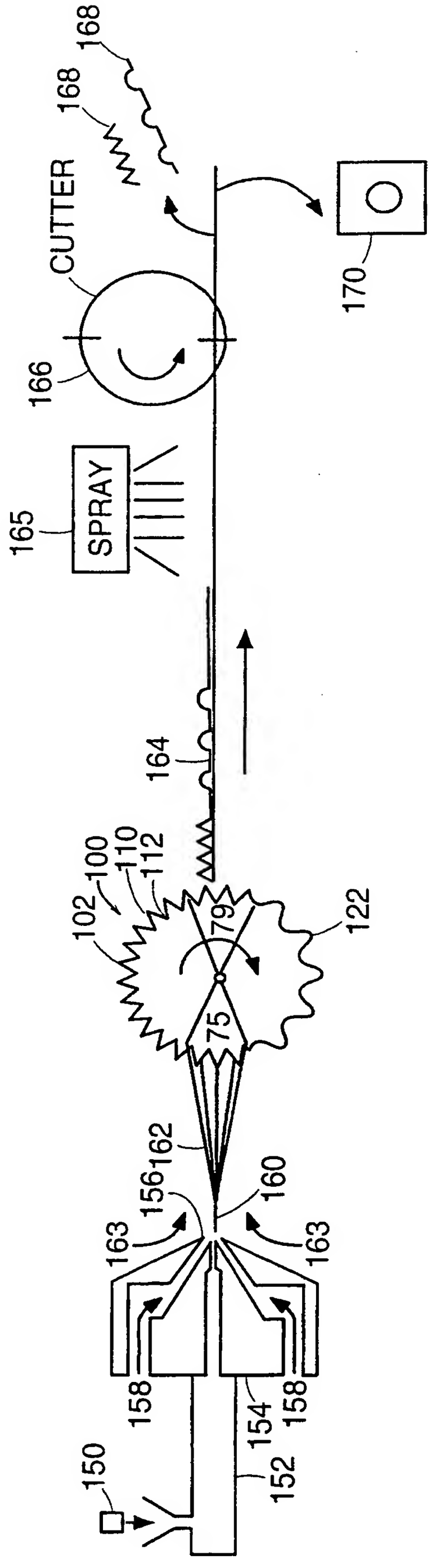


FIG. 7

PNSDOCID: <WO 0029656A1 IP>

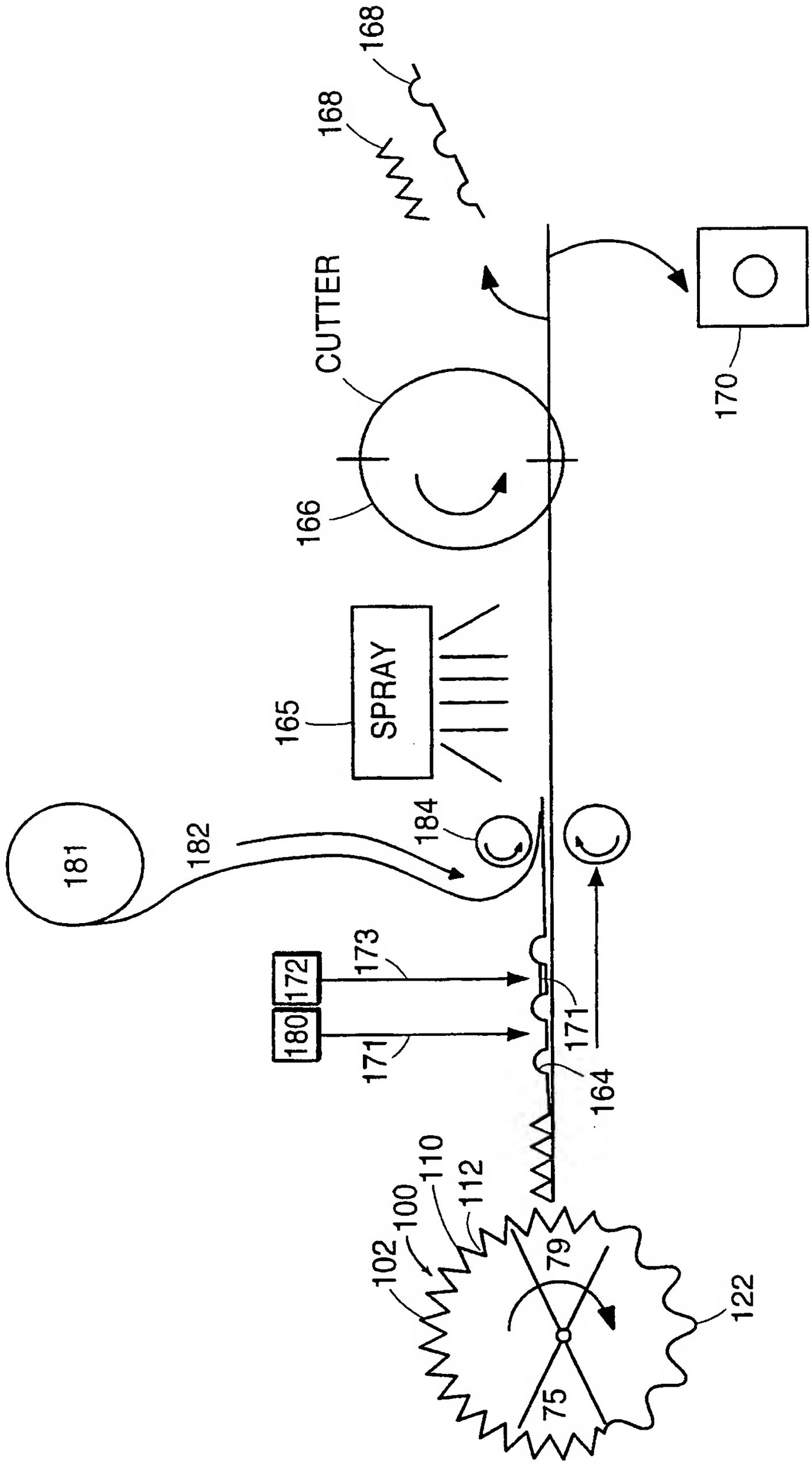

168
168
CUTTER
166
SPRAY
165
181
182
184
172
180
173
171
171
164
110
112
100
102
79
75
122
170

FIG. 8

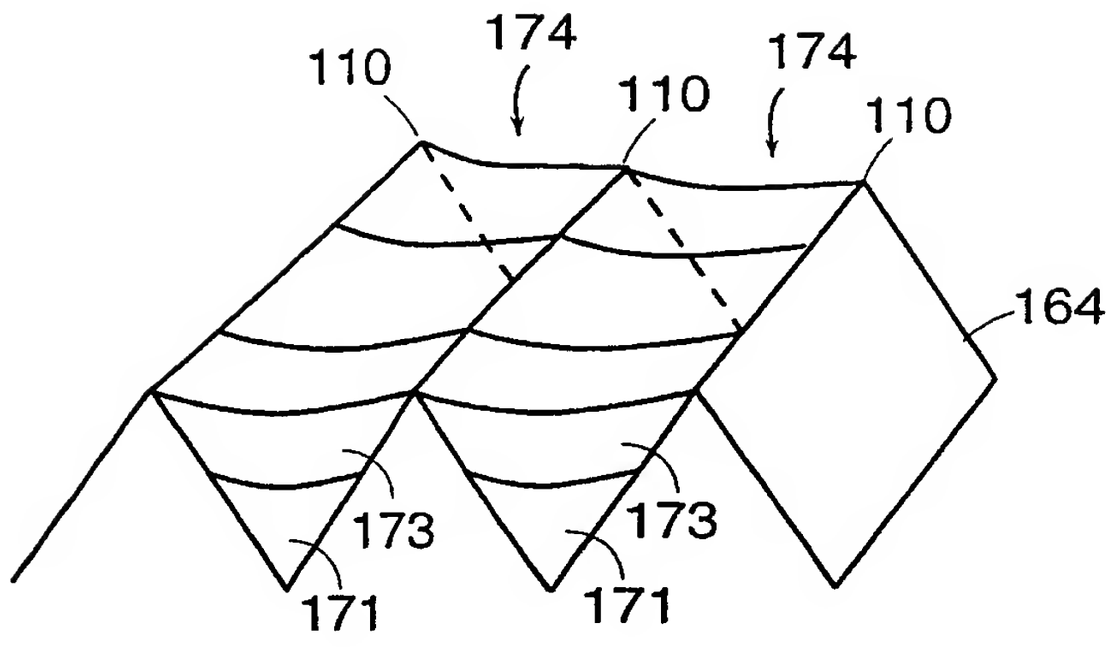


FIG. 9

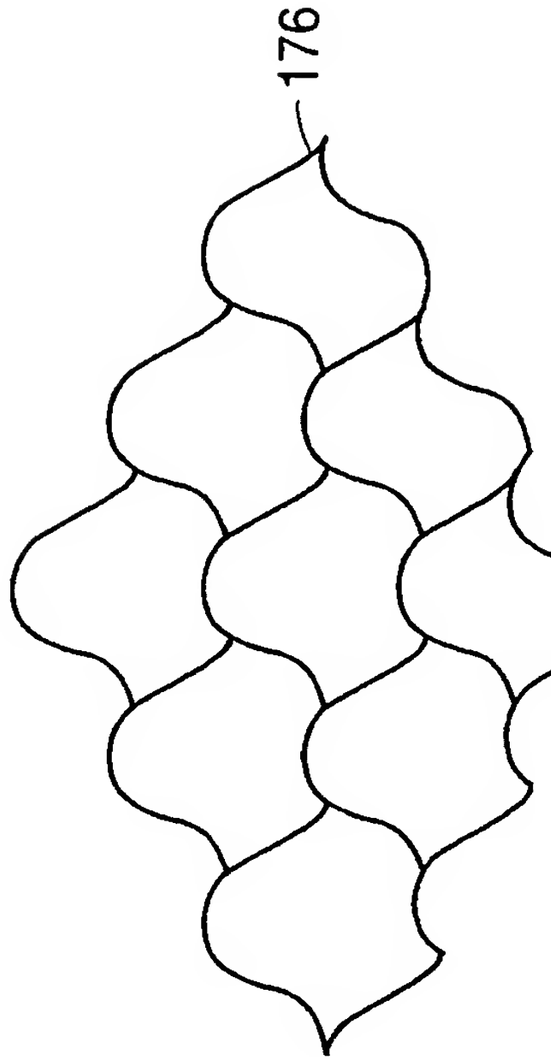


FIG. 10B

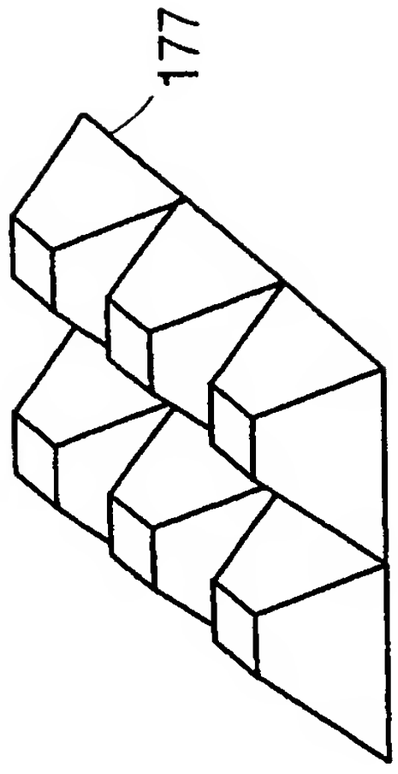


FIG. 10C

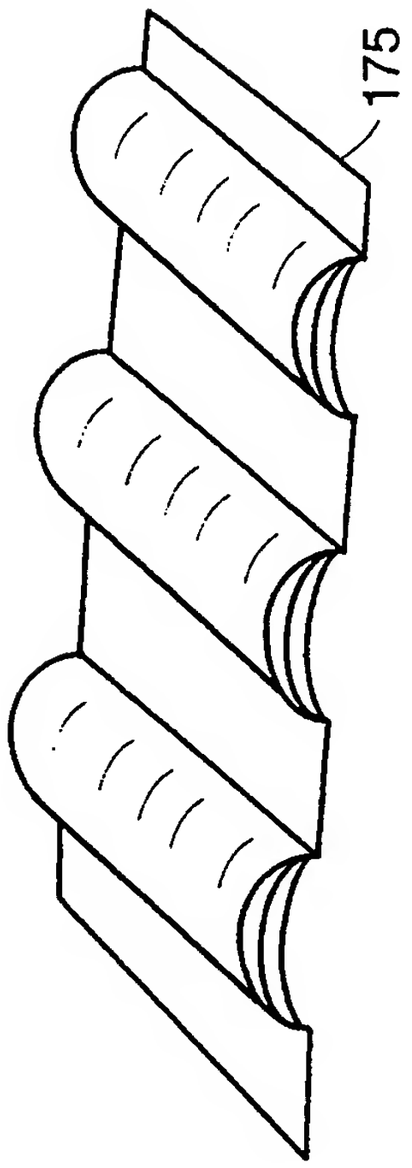


FIG. 10A

INTERNATIONAL SEARCH REPORT

Intern. al Application No
PCT/US 99/27294

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 D04H3/16 D04H1/54 D04H1/72 D04H3/03 D04H3/07

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 D04H B65H B01D D21F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	column 3, line 20 - line 59; figures 1-6	3

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 April 2000	02/05/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Joly, F

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INTERNATIONAL SEARCH REPORT

Intern ial Application No
PCT/US 99/27294

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 5 656 232 A (TAKAI HISASHI ET AL) 12 August 1997 (1997-08-12) column 4, line 39 -column 5, line 35; claim 4; figures 2,3	1,2,5,6, 8,19
A	US 3 878 014 A (MELEAD JAMES J) 15 April 1975 (1975-04-15) column 1, line 66 -column 2, line 65 column 4, line 2 - line 10 claim 1; figures 1,2	1-3,6,8, 10,11, 19,20
A	EP 0 460 310 A (ACCURATE PROD CO) 11 December 1991 (1991-12-11) column 1, line 47 -column 2, line 45 column 3, line 10 -column 5, line 49 claims 1,2,10-12; figures 1-6	8-11
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A	US 4 205 123 A (GRAMMER DON O ET AL) 27 May 1980 (1980-05-27) figure 1	4

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